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SOME IMPORTANT CHANGES IN THE PLANS FOR a new water supply for Cincinnati are recommended in the report of the second board of experts, which was published in full in the "Cincinnati Commercial-Gazette" of April 30. The general plan of the first board is unqualifiedly approved, with the exception of the high-level storage reservoir, which the second board would omit altogther, but several modifications of the plan are recommended. First of all, objections are urged to the site chosen for the intake, on account of local conditions affecting construction; and an alternative site discussed by the first board and abandoned because it is located outside the State, in Kentucky, is preferred. The proposed storage reservoir, the board considers, is located at the wrong end of the supply main, that nearest the pumping station, and could well be omitted, and a part of the money, only, put into an enlarged pumping plant. In regard to filtration, the report recommends that further studies be made before adopting any plans, and that mechanical filtration be taken into consideration. The original report recommended slow sand filtration. Various other changes in the details of the plans are suggested, including the use of steel pipe on one section of the conduit, an emergency connection with the Ohio River at the main pumping station, near the city, and two delivery mains from the main station. The proposal to provide for so large a future consumption per capita as 130 gallons per day is criticised, the reduction of the present consumption, rather than encouragement for its increase, being recommended for consideration and action. The roport is signed by all the members of the commission, Messrs. S. M. Felton, Henry Flad, Chas. Hermany, Clemens Herschel and M. L. Holman. Mr. Herschel, it will be noticed, takes the place of Mr. F. P. Stearn, who was originally selected to serve on the commission, but declined on account of other engagements. The original commission, which devised the plans under consideration, consisted of Messrs. John W. Hill, Samuel Whinery and Geo. H. Benzenberg. The report of these engineers was reviewed in Engineering News of April 2, 1896.

NEW WATER-WORKS FOR LOS ANGELES, CAL., to be owned by the city, have just been reported on at length by Mr. J. H. Dockweiler, City Engineer. The report recommends the development of a supply of some 50,000,000 gallons, designed to supply a population of 250,000, from the underflow by means of infiltration galleries over two miles in length, at two locations; a supply conduit of concrete, 5 ft. in diameter, 8 1-3 miles long, with a fall of 25 ft., and another of steel, 44 ins. in diameter and about five miles long; reservoir capacity of about 75,000,000 gallons; and nearly 500 miles of distributing mains, of which 319 miles would be 6 ins. in diameter, 1½ miles 40 ins., and the balance of intermediate sizes. The estimated cost of the works is about $4,500,000. The main part of the city is now supplied by the Los Angeles City Water Co., and sections of it by the Highland Water Co. and the West End Water Co. The estimates provide for either the acquisition of a part of the private works or the building of entirely new plant. There is talk of buying the entire plants of the private companies, but nothing definite has been done towards providing money for either the purchase or the construction of works, if we are correctly informed. The people, however, have voted in favor of municipal works.

THE RIGHT OF THE TOWN OF WESTERLY, R. I., to construct water-works in competition with the existing plant of the Westerly Water-Works Co. has been affirmed by the U. S. Circuit Court for the District of Rhode Island. In 1895 the town instructed its council to agree with the water company, if possible, on a third referee to determine the price the city should pay for the company's works, and in case an agreement could not be reached to contract for works to be owned by the town. Later, the town took steps to build works, but the company opposed such action, the matter finally reaching the U. S. Circuit Court, which granted the preliminary injunction just dissolved. The company alleged that it had an exclusive right to supply water in Westerly, even against the town, but the court holds the contrary to be true. The opinion, which is interesting and involves some complicated points in local law, as well as some broad general principles, is given in full in the Westerly "Sun" of April 21, 1897.

THE PLANT OF THE LONG ISLAND WATER SUPply Co., of Brooklyn, will soon be transferred to the city after over six years of litigation. The works were built in 1881 to supply the town of New Lots, which in 1886 was annexed to Brooklyn as the 26th Ward. In December, 1890, some of the Brooklyn city officials contracted to buy the works for the city for $1,250,000. The purchase was prevented through a taxpayer's injunction, the complainant alleging that the sum named was excessive. The matter went to the Court of Appeals, which decided that the time for buying the works, as provided in the annexation act, under which the officials were proceeding, had expired. In 1892 the legislature authorized the city to buy the works at an appraised valuation. The price was fixed in 1893 at $570,000, and since that time the matter has been in the courts. The present and final decision has been rendered by the U. S. Supreme Court. In this connection it is interesting to note that a company undertook to construct the original Brooklyn water-works and was bought out by the city after having let contracts for the work; also that two towns in the territory recently annexed to Brooklyn were first supplied by a private company. One of the towns, Gravesend, built works before annexation, and the plant in the other town, New Utrecht, has been bought by Brooklyn since. Three other companies, besides the Long Island Water Supply Co., are still in operation in the annexed districts of the city, two having small plants and one, the Flatbush Water-Works Co., having 55 miles of mains.

SLOW SAND FILTRATION FOR THE WATER SUPply of Albany, N. Y., recommended by the water commissioners, as noted in our issue of Feb. 18, 1897, has been approved by the city council. Covered filter beds with a daily capacity of 15,000,000 gallons, settling basins and a centrifugal pumping plant are included in the plan adopted, in accordance with a report by Mr. Allen Hazen, St. Paul Building, New York city. The estimated cost of the work is $478,000. Mr. Geo. I. Bailey is superintendent of the Albany water-works.

ALL WORK DONE BY PROSPECTIVE BIDDERS for a new water supply for Hoboken, N. J., suddenly came to nought on April 26, through the rescinding by the water commissioners of the resolution calling for bids on April 30. A protest against this action was filed with the water commissioners, before the vote was rescinded, by the T. A. Gillespie Co., which stated that it had been making extensive preparations to submit a bid, including surveys and estimates and the securing of chemical analyses. Notwithstanding the protest, the resolution was rescinded and a resolution was passed to renew the contract with the Hackensack Water Co. for 25 years from Nov. 15, 1897, the company to accept a 10% reduction on the rates fixed by present contract. The city of Hoboken owns the water mains and pays the water company a percentage of the revenue collected from private consumers.

THE MOST SERIOUS RAILWAY ACCIDENT OF THE week took place on the Wheeling & Lake Erie R. R., at Carpenter's Bridge, two miles west of Warrenton, O., on April 29. A west-bound freight train drawn by two engines was crossing the bridge. The first engine and 20 cars crossed safely, but the second engine and 14 cars plunged through into Short Creek. The engineer of the train was killed, and the fireman and a brakeman were seriously injured.

THE MOST DISASTROUS FIRE that has occurred in Pittsburg, Pa., since 1845, except the fires during the riots in 1877, took place early in the morning of May 3. It destroyed the wholesale drygoods store of Jos. Horne & Co., valued, including stock, at $1,500,000; the wholesale grocery of T. C. Jenkins & Co., valued at $650,000, and several smaller buildings, the total loss being estimated at over $3,000,000. The fire broke out about midnight in the store of T. C. Jenkins & Co., and is believed to have originated in a barrel filled with rags and refuse of all kinds, including the remains from the dinner buckets of the employes of the establishment. The night watchman found the fire at the foot of an elevator shaft, and as it did not appear at all serious he attempted to put it out by means of a chemical fire extinguisher, but the fire caught the oil on the elevator slides and instantly got beyond his reach. The destructive extent of the fire seems to have been due to a combination of primary and secondary causes, including the barrel containing rags and greasy materials likely to cause spontaneous combustion, its location at the foot of a combustible elevator shaft, and delay of the watchman in calling the fire department.

THE ROOF OF THE TUNNEL of the Terminal railway at Wheeling, W. Va., caved in about 25 ft. from its south end on April 26, leaving a hole 15 ft. diameter in the roof. The accident took place just after a freight train had passed through. A local newspaper says that several tons of earth fell from the roof, carrying with the mass the heavy timbers which gave the roof but a weak support, and that the cave-in was caused by the damp condition of the ground. The roof was about 20 ft. thick where it fell in.

THE DES MOINES RIVER broke through the levees at Ottumwa, Iowa, on April 26, flooding a large portion of the town. Railway embankments were undermined, stopping railway communication. Bradyville, 18 miles north of Ottumwa, was also flooded, and a large section of farming country in the neighborhood is under water.

A BOILER EXPLODED at the water-works in Middletown, Ind., on April 28, wrecking the boiler house and injuring two men. The boiler is said to have been a new one.

THE CROWN SHEET OF A LOCOMOTIVE BOILER was blown out on April 28, at Montour Junction, on the Pittsburg & Lake Erie R. R. Four men were scalded, two of them seriously.

THE MOTOR CARS ON THE BROOKLYN BRIDGE are being temporarily replaced by the old cable system, pending the equipment of the cars with heavier axles. The old axles are too weak to support the extra load put upon them by the new service, and six of them have failed already. The new axles will be ⅝-in. greater in diameter, and a week or more will be consumed in making the change.

THE IRON TORPEDO RAM "ALARM," 800 tons displacement, now lying at the New York Navy Yard, is to be sold at auction by the government. The ram was built in 1874, chiefly for the purpose of testing a new form of propeller, which would enable a rudder to be dispensed with, but it was never a marked success.

THE CAUSE OF THE FIRE WHICH DESTROYED the power house of the Union Traction Co. in Philadelphia on March 3 has been reported by Mr. William McDevitt in the quarterly fire report of the National Board of Fire Underwriters as follows:

A hoisting crane, belonging to an overhead crane, which was held back by resting on a guard rail, was drawn from its position by a moving of the crane by employes at the other end of the room. This caused the chain to swing down against the fly-wheel of the engine, from which it rebounded and struck against one of the lead heads to which the conductors were attached on the generator, causing a violent flash. Another employe grasped the dangling chain with his hand, but finding it too hot, took his hat, and securing the chain prevented it from doing further damage. The swinging contact (the chain being grounded) produced a short circuit for an instant, but the machine resumed its normal speed intact until the engine was stopped. In the meantime molten metal had been spattered down into the flywheel pit, setting fire to a board partition at that point, and at the same time igniting the insulation on the conductors. Every effort was used to extinguish the fire, but owing to the dense smoke the attempt was unsuccessful. Upon the arrival of the firemen the same obstacle was met, preventing access to the cellar, where the fire at that time was confined.

The primary cause of this fire, from a grounded hoisting chain causing a foreign contact, may be classed as an accident, but the occurrence of a similar accident (without causing fire) at another establishment of like character, should serve as a lesson to be observed in the future management of all such risks.

A TEST OF NINE CHEMICAL FIRE EXTINGUISHERS of different makes was made at the carshops of the Pennsylvania Co. on April 20, with a view to determining which kind should be used on railway trains, in order to comply with the Ohio state law. The law provides that one coach on each train shall be provided with an extinguisher the first year and one additional coach each succeeding year until all are supplied. The tests were made under the supervision of the State Railway Commissioner, on whom devolves the duty of selecting the kind of extinguisher to be used. The tests were witnessed by the representatives of a large number of railways. The extinguishers were of 2, 3 or 4 gallon capacity, and were of the following makes: Gem, Firemen's Excelsior, Rex, Underwriter, Stemple, Muskegon, Guardian, Hensley and Babcock. In making the tests fires of the same kinds of combustible were burned from 17 to 30 seconds, when the extinguisher was applied. The Stemple extinguisher was exhausted in 40 seconds and the fire had to be put out by the fire department. The Muskegon was exhausted in 1 minute, when the fire was almost out. The other extinguishers succeeded in putting out the fire in times ranging from 1 min. to 1 min. 35 secs.

THE WATER-WORKS AT HOLLISTER, CAL.

By C. E. Grunsky, C. E.*

Until two years ago Hollister, the county seat of San Benito County, population about 2,500, was supplied with water from wells. The quality was not entirely satisfactory and operating expenses were considerable. A better source of supply was discovered in Pescadero Creek, a

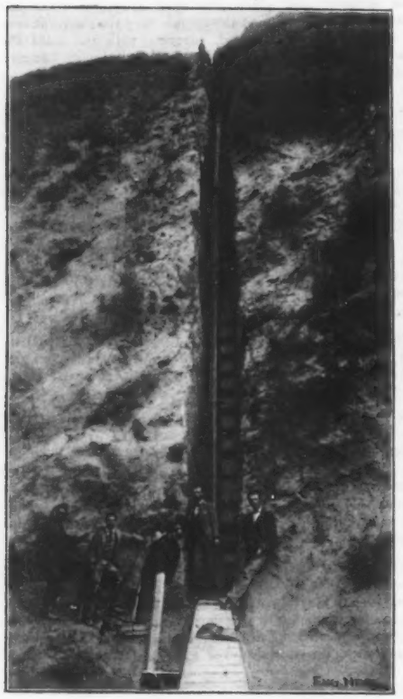


Fig. 1.—Bird Creek Crossing on Pipe Line; Hollister, Cal

small coast range stream flowing into San Benito River from the west, about ten miles southward from Hollister, and the new works have been put in by the Hollister Water Co. to make this supply available.

The creek flows through a valley about three miles long and half a mile wide in a bed of coarse granitic sand. During the dry months of summer its flow sinks in the gravels and sands at the head of this valley, rising again in part at a point in the creek channel about a mile from the valley's lower end. At several points in the valley are cienagas or moist spots, indicating the presence of impervious subsurface strata which force water toward the surface.

To collect the water supposed to be flowing in the sand and gravel under the creek bed, a water gallery was constructed consisting of a box culvert with open bottom resting on occasional piles of broken rock. This was placed at a depth of five to eight feet below the creek bed, bifurcating near its upper end to send a branch toward a cienaga. Access to this gallery is afforded by several manholes. The minimum amount of water thus collected is about 200,000 gallons per 24 hours, and it is conducted in a 14-in. pipe of redwood staves about 2,000 ft. to a point at the northern edge of the valley, where the supply from the creek bed is re-enforced with a flow from a sump that has been sunk about 25 ft. below the valley surface. When more water is required it is proposed to extend a gallery from this sump directly across the northern portion of the valley to a point in the creek bed where there is a natural inflow from below.

The water is conducted from the valley of Pescadero Creek at the level of the bottom of the sump above referred to northward in a fairly direct line toward Hollister. The first ridge of hills is pierced by a tunnel 1,400 ft. long. The wooden pipe leading through the tunnel terminates at its lower end in a concrete settling basin, 10 ft. wide, 30 ft. long, about 3 ft. deep, in which four cross-walls rise to near the water surface. By an arrangement of gates in alternate ends of the cross-walls the floating out of accumulated sands is facilitated. A 6-in. wrought iron pipe connects a small inlet with a small outlet chamber, thus enabling water to be passed by the settler while it is being cleaned out.

The pipe line from this point follows the eastern slope of the hills, being held reasonably close to the hydraulic grade line, but always a little below it. This was done to allow of the use of wooden pipe. Wooden pipe built of redwood staves was used wherever the pipe was less than 100 ft. below hydraulic grade. All other pipe sections were constructed of riveted sheet steel. The wooden pipe is 14, 12 and 10 ins. diameter in aggregate lengths of 3,140, 11,380 and 14,010 ft., respectively. The steel pipe between the several sections of wooden pipe is 10 ins. diameter. The weight of the steel used is No. 14 and No. 12 B. W. G., according to pressure. The pipe line crosses four principal depressions, besides a number of minor ones. Of these but one, Bird Creek crossing, deserves special mention, and this is shown in Fig. 1. At this creek the pipe line has received a trestle support from which it rises abruptly, climbing a very steep hillside. A special bend was used here, as elsewhere, to reduce the radius of curvature, and care was taken to bed it well against the solid material into which the trench had been cut, so as to prevent its being blown out by the great pressure of water at this point, the depth below grade being 470 ft. The slipping of the pipe in the steep trench has been guarded against by building concrete collars around the pipe and anchoring these well into the soft sand rock of the hillside. The trench was refilled with material excavated at convenient points, and held in place by log cribs. Precautions were also taken to turn rainwater past the upper end of the steep section of the trench, to prevent a cutting out of the fill.

The riveted pipe is of the character that has become standard in the West. It was furnished in sections, generally 22 to 26 ft. in length, which were united together by means of a lead joint formed in the usual way with collar and sleeve. Short lengths and special bends were used to overcome sharp curves. The junction between wooden pipe and iron pipe is effected by means of short cast-iron sections, into the bells of which the respective pipe ends are fitted. Oakum is used to fill the joint between wood and iron.

Fig. 2.—4-in. Stand-pipe and Blow-off on Wooden Pipe Line; Hollister, Cal.

Where sharp bends on the wooden pipe could not be avoided, cast-iron specials were used.

At a point about four miles from Hollister the pipe line is dropped down a hillside, making a descent of 380 ft. in an 8-in. steel pipe, 1,220 ft. long, to the Sally Flat reservoir. This reservoir is concrete lined, and has a capacity of 400,000 gallons. The fall at this reservoir was introduced with a view of ultimately utilizing it in generating a limited amount of power. The reservoir has the shape of an irregular pentagon; it is almost entirely in excavation, with side slopes of 1 to 1, and it is covered with a light board roof. From it a pipe line consisting of 1,270 ft. of [illegible]-in. wooden pipe and 22,390 ft. of 8-in. riveted steel pipe leads into a service reservoir located in Hollister on an isolated hill. This has a capacity of about 200,000 gallons and is to be enlarged by raising its brick lined sides to 250,000 gallons. The fall

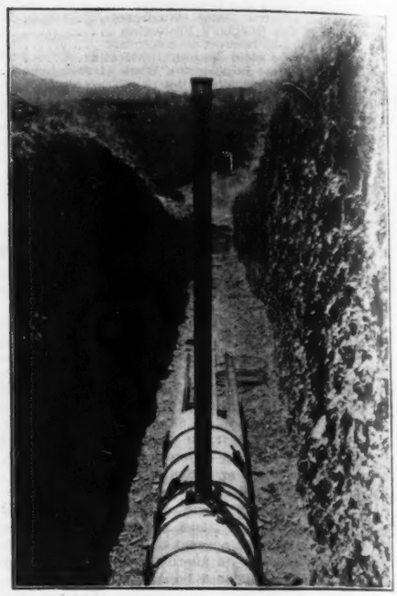


Fig. 3.—2-in. Blow-off Pipe and Cock on Wooden Pipe Line; Hollister, Cal.

from the Sally Flat reservoir to the Hollister Hill reservoir is 87 ft.

An overflow and slush pipe from the Sally Flat reservoir lead into a 10-in. ironstone pipe about ¼ mile long, which delivers its flow into a waste-water reservoir covering about eight acres, when full, to an average depth of 5 ft. The water there accumulating is for use in irrigation. The outlet of this reservoir is in the form of an iron pipe opening into a concrete manhole (through one side of which the overflow from the reservoir is dropped), and thence by iron pipe and a few lengths of wooden stave pipe to an open ditch.

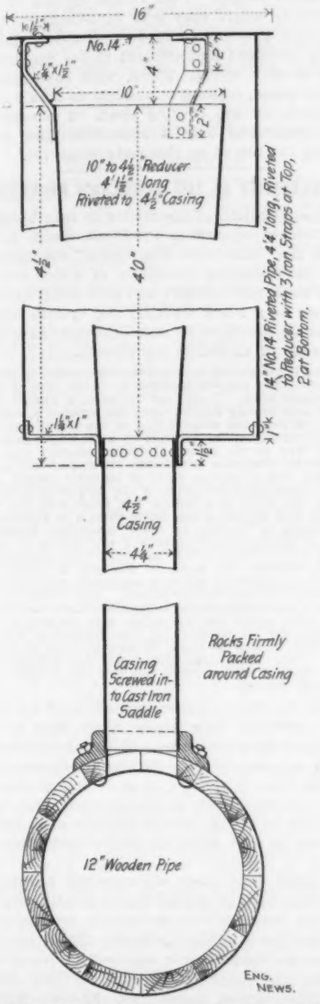
The total fall in the grade line from the settling basin to top of hill at Sally Flat reservoir is 72 ft. The hydraulic grade line was a broken one owing to the different classes and dimensions of pipe used. Between the points named the pipe is 33,383 ft. long, composed of 268 ft. of 14-in., 11,376 ft. of 12-in., 12,763 ft. of 10-in. wooden pipe, and 9,376 ft. of 10-in. steel pipe.

The capacity of the main pipe line above the Sally Flat reservoir is estimated at 900,000 gallons per 24 hours. No test of capacity could be made at the time of completion because the supply was not fully developed.

Among special features may be noted the overflows placed on the wooden pipe at main summits. It was thought desirable to keep the pipe line well below the hydraulic grade line so that until its flow is to be utilized for power development its rated capacity may be exceeded. It is thus made possible to send more water into the waste-water reservoir for irrigation than could otherwise have been done. The position of the grade line, eight or ten feet above the pipe, made it necessary to raise the overflows higher than is ordinarily done, and led to the adoption of the design suggested by Mr. D. C. Henny, M. Am. Soc. C. E., of a 14-in. stand-pipe, terminating in a flaring pipe covered with a cylindrical hood, as shown in Fig. 2. The pipe rises vertically to hydraulic grade; its uppermost section increases in a length of 4 ft. from a diameter of 4½ ins. to 10 ins., in order to reduce velocity of outflow and to avoid additional head

*San Francisco, Cal.

consequent upon forcing full supply through a smaller pipe. A 14-in. hood shields and conceals the open top of the overflow pipe, and the overflow is received upon a bed of cobbles. Three of these relief outlets have been provided, and they protect the pipe line against the accumulation of pressure when the gates are closed. It was foreseen that accidents to the lower sections of the pipe line, such as damage by a landslide, might at any time necessitate a sudden closing of a gate near its lower end. Were no overflows in use the pressure would rise to that represented by the height of the inflow. With the overflows in service the increase of pressure is limited. These


16"
No.14
10"
10" to 4½" Reducer 4' long Riveted to 4½" Casing
4'0"
14" No.14 Riveted Pipe, 4'4" long, Riveted to Reducer with 3 Iron Straps at Top, 2 at Bottom.
4½" Casing
4¼"
Casing Screwed into Cast Iron Saddle
Rocks Firmly Packed around Casing
12" Wooden Pipe
ENG. NEWS.

Details of Overflow Stand Pipe for Gravity Conduit, Hollister Water-Works. C. E. Grunsky, Consulting Engineer. Excelsior Wooden Pipe Co., San Francisco, Contractors.

overflows also serve as air vents, which are necessary on all summits. The ordinary type of air valve, with hard rubber ball, has been used at several points on the steel pipe. On the secondary summits of the wooden pipe the air vents are in the form of an open 2-in. pipe carried up the hillside to above hydraulic grade, as shown in Fig. 3. At minor summits a small ¾-in. pipe, with ordinary cock, serves as an air vent.

The service reservoir in Hollister is kept full by an automatic gate controlled by a float.

The water development was well started and contracts for different classes of pipe work were let before Mr. Hubert Vischer, C. E., was put in charge as Chief Engineer. Most of pipe line location and detail were determined by him. The writer was Consulting Engineer during the last stages of the work after Mr. Vischer was called away by other engagements. The pipe work was done by the Excelsior Wooden Pipe Co., of San Francisco, Cal., of which Mr. D. C. Henny is General Manager. All excavating, trenching, reservoir construction, etc., was done by day's labor.

SYSTEMS OF SEWER FLUSHING AND SUGGESTIONS ON FLUSH-TANK DESIGN AND CONSTRUCTION.

By Andrew Rosewater, M. Am. Soc. C. E.

Although automatic sewer flushing devices have been in general use for over twenty years, I am not aware of any extensive experiments having been made to determine their efficiency in practical use. Much has recently been written and accepted as conclusive, without analysis, tending to show that hand flushing of sewers is preferable to and cheaper than automatic mechanical flushing. These views have been given wide publicity through the special efforts of water-works officials, whose companies are interested in reducing the water consumption to a minimum, in view of contract obligations to furnish free water for sewer flushing purposes.

In the summer of 1892 I made experimental tests on 20 different lines of sewers in the city of Omaha, Neb. These sewers had diameters ranging from 8 ins. at the upper end, to 15 ins. at points from 800 ft. to 1,500 ft. below, and were laid upon gradients from 0.4% to 6%. Each of these sewers terminated in an automatic flush tank at its upper end. The tanks had storage capacities varying from 160 to 400 gallons each, and their siphons discharged at rates varying from 6½ gallons, in a few instances, to from 9 to 15 gallons per second in the greater portion of them. From these investigations it was found that each of the discharges developed effective scouring depths in the sewer pipes for distances ranging from 800 ft. to 1,500 ft. below the tanks.

In 1893 I was engaged to design plans for flush tanks for the city of Denver, and after a number of them were completed, Mr. H. F. Merryweather, then Chief Engineer of Public Works of that city, instituted tests on two long lines of sewers, at my request. These sewers had uniform diameters of 8 ins. and their grades ranged from 0.4% to 2%. The tanks averaged about 400 gallons capacity each, and discharged at the rate of 11 gallons per second. The depths of flow and velocities attained averaged as follows:

First 200 ft., depth 8 ins. to 6 ins., velocity 5.6 ft. per sec.; next 200 ft., depth 6 ins. to 5 ins., velocity 2.8 ft. per sec.; next 400 ft., average depth 4 ins., and velocity 2 ft. per sec. From this to the terminal point, 2,000 ft. below the tanks, the depth of flow ranged from 3 ins. to 2 ins., with rates of flow from 1.3 ft. to 1.9 ft. per sec. These results, being entirely independent of any normal developed flow from sewer connections, prove conclusively the value of automatic sewer flushing, where the quantities discharged at requisite high velocities are provided for and judiciously designed with due regard to specific sizes of sewers to be flushed. In the earlier works constructed at Memphis and other towns, the tanks contained about 112 gallons and discharged in 40 seconds, or at the rate of 2.8 gallons per second, giving an initial velocity of 2 ft. per sec., as against initial velocities of 5.6 ft. per sec. developed in the recent tests referred to, or a trifle over one-third the initial velocity now obtainable from later designs. The effect of these designs, in giving a three-fold initial velocity of discharge and a three-fold quantity, is to develop a marked increase in the scouring reach of the flushing stream.

The adjustment of the various early styles of siphons and mechanisms was delicate, and their certainty of operation depended largely on exact vertical setting and very unreliable reprimings devices, and in many cases upon a continuous high speed in flow. When confined to a low rate of flow, the service pipes choked up and the tank failed to work. This led to a lack of confidence in automatic tanks generally, and induced many engineers to condemn such devices, owing to their wasteful use of water and unreliability of continuous operation.

In 1895 a controversy arose between the city of Omaha and the Water-Works Co. over the hydrant tax, and among other things charged by the company against the city was an inordinate waste of water in the flushing of sewers. The charge was made that 3,500,000 gallons were daily wasted in the city flush tanks at an extraordinary loss to the company. Upon making the investigation, the writer discovered that there was actually a total of 1,800,000 gallons being consumed daily in operating tanks embraced in 100 miles of sewers.

The sewer department was operated under a political system of control, the sewer commissioner knew very little about sewerage, and his subordinates but very little more. There really was no need under existing conditions of using more than 600,000 gallons daily, if the inflow was properly adjusted. In other words, in view of the turbid nature of the water, about 2,000 gallons flow per 24 hours was necessary to maintain in each ½-in. pipe an interrupted flow into the tank. For upon making computations based upon the well-established theory that sediment will gradually deposit in currents having velocities under 2 ft. per sec., and applying the theory to the flow of muddy water in pipes, it will be found that to prevent service pipes from choking from the self-contained mud of the supplying stream, they should have a self-scouring capacity, which, as stated, requires a velocity of flow of not less than 2 ft. per sec. Upon this basis various-sized service pipes must, to avoid sediment, discharge as follows: ¾-in. pipe, 3,980 gallons per 24 hours; ½-in. pipe, 1,768 gallons per 24 hours; ⅜-in. pipe, 995 gallons per 24 hours; ¼-in. pipe, 445 gallons per 24 hours.

It is thus obvious that to preclude the stoppage of flow in pipes supplying unfiltered water and still be economical, their size must be sufficiently small to furnish such supply under velocities of at least 2 ft. per sec. I had personally fallen into the common error of engineers in previous years of specifying for service pipe dimensions from ¾ in. upwards, varying with the distances of the tanks from the water mains. To show that this singular error was a common one, I quote from the report of the city engineer of Memphis for 1886 regarding flush tanks in that city. He says:

> The excessive quantity of mud in the water is one chief cause of trouble, the small ¾-in. supply pipes of the flush tanks becoming clogged with mud, making it necessary to replace these in many places with large pipes.

Thus it will be noted the remedy applied was just the reverse of what should have been done. The effect of enlargement must have been to reduce the velocity of flow and render more certain the filling up of the supply pipe with mud, only it took a little longer to fill it up.

If the service pipes be reduced to a diameter of ¼ in., which will meet the requirements of 99% of the tanks in use in the United States, a general saving in water of from 50% to 75% can be effected, besides avoiding the frequent choking up of the tank supply pipes and their discontinuance of operation. The actual additional expense of water to corporations owning a water-works system for sewer flushing is the value of additional coal consumed and the cost of handling it, as all other expenses of operation would substantially be the same. This can be safely assumed at not exceeding 1½ cts. per 1,000 gallons.

Thus it will be seen that the actual average additional annual outlay per tank to water companies in cities similarly situated to Omaha would, on the basis of 500 gallons per day, amount to $2.73. This could readily be adjusted with the use of ¼-in. service pipes. With the usual prevalent condition in cities, two men with a horse and wagon can easily take care of 300 tanks and maintain them in repair and good condition. The annual expense of these men and horse and wagon, with repair tools, etc., will not exceed $2,000. This makes the annual labor expense per tank $6.67. For purposes of comparison assume the average cost per tank for construction, inclusive of pipe connections complete, at $100, then adding 5% of cost as annual expense, we have the following: Water, $2.73; labor, $6.67; interest, $5; total, $14.40 per tank per year. If flushed by hand labor there are practically three methods available. (1) Water carts; (2) direct portable hose connections to hydrants; and (3) connection with pipe mains and hand valves.

The first method will require one team and two men. These men could handle at most 25 tanks per day. At $1.50 per man and $1.50 for the team we have labor expense of $4.50 for 25 tanks, or 18 cts. per day per tank, or $65.70 per year. Adding

to this the cost of water, $2.73, we have a total of $68.43, as against $14.40 by automatic flushing.

The second method will require two men with hose and a horse and wagon. They can handle at most 30 tanks daily at an outlay for labor of $4, or $46.50 per year per tank, which, added to the cost of water, would amount to $49.25, as against $14.40. In this case, as in the previous one, the velocity of discharge with a 2½-in. standard hose would be limited to about 3 gallons per second, and in the latter case, if larger hose be used, the tanks handled per day will be materially reduced.

In the third case the cost of manhole, with water main and valve, will equal if not exceed that of the flush tank and its appurtenances. The valves can be handled by one man, who with a horse and wagon can manipulate 40 tanks daily. At $75 per month for man and horse, without allowance for repairs of valves, we have $22.50 for labor per tank per year; adding 5% interest on investment and $2.75 for water, as in the case of the tanks, we have a total annual expense of $30.25, as against $14.40 per automatic tank. Thus it will be seen that with daily flushing of sewers the cheapest system by hand flushing costs over twice as much as automatic flushing, while the common prevalent plan of water cart flushing costs four times as much. With automatic flushing under the case outlined, the work is certain, regular and specific. With the best of hand systems it is sure to be neglected in stormy and extreme cold weather, and in the case of ordinary hose flushing, the velocity of inflow will be from one-third to one-fifth that of automatic tanks. On the other hand, with the hand valve and direct water main connection, the flush can be very effective, but the quantity used cannot be made as specific as by the automatic process.

With this analysis of the relative merits of the various methods of flushing sewers, and an illustration of what I deem one of the main causes of pipe stoppage, wastefulness of water in the flushing devices, it may not be out of place to make a few more suggestions as to the construction, operation and care of the flushing devices in general use, viz., automatic siphons.

The operation of all of them, whether with or without movable parts, depends (1) upon a proper design, and (2) upon a strict construction in conformity with it. The height of the inner limb above the base of the tank should be very specific in the plan and constructed in strict accordance therewith. A siphon may operate once and not a second time. This is due to a lack of proper repriming. In other words, the air in the siphon has not been replaced after discharge and brought to a normal condition. In that case water may rise and overflow into the inner discharging limb as fast as it enters the tank. As all automatic siphons are designed for a small rate of inflow, the water should not be turned on too fast simply because the observer hasn't the patience to wait for the tank to fill up as it is designed to do.

This same fault operates to prevent repriming through a sniff hole. The latter requires a certain length of time to admit the exhausted air to reprime the siphon. If the water is turned on too fast, it will rise from the mouth above the sniff hole before air enough has been admitted to reprime the siphon to normal condition. If through oversight this has been permitted in any siphon, the only way to remedy the evil is forcibly to raise the outer hood vertically above the water level so as to fill it with air and then lower it steadily into place. A faulty casting with crack or hole in any part of the siphon will prevent air compression. In such a case it should be replaced. It is always well to have a dirt pan under the cover of each tank, and at the same time provide for some ingress of air, either by an outer pipe connection from the sewer to above the water line in the tank, or by perforations in the cover. Let it be remembered that in all constructions there is nothing but what requires occasional attention and repair, and the automatic flush tank is no exception. If looked after as it should be, it cannot fail to prove itself the best and most economical medium for sewer cleansing.

The desired rate of discharge of siphons should be stated, so as to place all devices upon a common standard of capacity test. The storage capacity based upon quantity required for each discharge should be designated to secure a common standard of tank capacity. To develop the highest efficiency the sewer should be connected to the tank with an increaser, so as to avoid loss through entry. These suggestions cover leading features relative to sewer flushing and tank design that are not to be found in published works or reports upon the subject. They are, however, too important to be ignored or obscured.

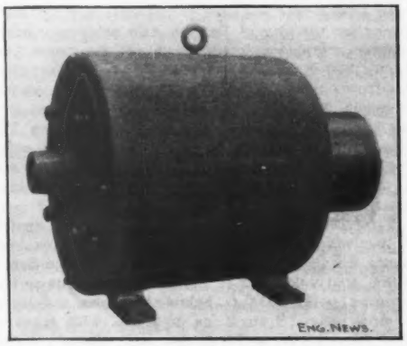
A STEEL-CLAD ELECTRIC MOTOR.

The accompanying cut shows the outside appearance of a new type of electric motor recently put on the market by The C. & C. Electric Co., No. 143 Liberty St., New York city. The following is a description of its principal features:

The frame consists of a soft steel shell, with radial poles projecting inward. The shell is capped at each end with a circular end plate, which carries the bearings and also the rocker arm support. The machine has four poles and magnet coils. The coils may be readily removed after taking out the armature, and are interchangeable. The armature is of the drum type, built up of thin laminae of soft iron, well insulated to provide against Foucault currents, and having the conductors laid in slots, the coils being wound on forms.

The brush holders are of the reaction type, securing a flexible and even pressure of the brushes with a minimum wear, and of such design that the brushes maintain a constant relative position on the commutator, thereby providing against the necessity of shifting the brushes forward when they have been shortened by wear.

The shaft is of steel and of such proportions as to insure rigidity and ample carrying capacity,



Cylindrical Steel Clad Electric Motor.
Made by The C & C Electric Co., New York City.

and is provided with self-oiling bearings, with large oil wells.

The cylindrical form of this machine makes it well adapted to all cases of direct connection, either through gears or otherwise. The gear shaft boxes can be placed on the shell at any convenient position, as the distance from the shaft to the outside of the shell is always the same. The machine itself can be placed in any horizontal position, thus making it well adapted to run as a ceiling motor, or attached at any angle to an "A" frame, or to bolt to the bed plate of any machine or tool with which it may be combined, the circular form of the end plates allowing them to be bolted on with the oil wells always in the proper position.

The ironclad magnetic field is ideal in its compactness, its circuits of minimum length and its freedom from "external field," or magnetic leakage, all of which qualities effect a saving in magnetizing force, and consequently a gain in efficiency.

The outer shell also forms a protection to the motor, preventing the admission of dust or dirt or dampness. The commutators are placed inside the shell, and none of the moving parts, except the pulley, pinion or coupling are outside of the shell, which secures safety, not only to the operator, but also to the armature of the machine.

As the shell is of steel, ⅝ in. or more thick, it may be tapped into wherever desirable, as in a case of direct application to machine tools or other classes of machinery, provided iron bolts are used. The armature can be handled without danger to the winding, the conductors being below the surface of the armature.

The makers guarantee that no part of the armature conductors, field conductors, brushes or commutator will show a heat of more than 75° C. above the surrounding atmosphere, and an efficiency of from 85° to 92°, depending on the size of the motor.

The machine can be furnished for special applications. First, with speed regulation by means of a field controller, giving a speed range of from full speed down to 2-3 of full speed, with a proportionate output. This avoids the use of series-controllers where they may be objectionable. Second, back geared to any desired speed, making it a very compact and efficient motor for driving a shaft at slow speed. Third, with back shaft and change gears, making it possible to obtain a range of speeds on the driving shaft by changing the gears, requiring only a moment's time and involving the use of no rheostats whatever.

ELECTRICITY IN THE BURGLAR'S PROFESSION.

The application of electricity to safe-breaking is described in an article by Lieut. Saml. Rodman, Jr., in the "American Electrician" for March. He gives the following directions, of which it is to be hoped some safe burglar will soon avail himself, so that we may learn whether the system works as well in the hands of an actual burglar as it does in the hands of an expert electrician:

A wire is connected to a convenient source of electricity and the electric current brought up to the safe or vault to be operated upon. Take, for instance, a 110 or 220-volt system, and having figured upon the amount of energy required, connect the wire to one of the mains and lead to the safe, where contact is made by attaching it in any convenient way to the metal. Connect another wire to the other main, interpose a suitable resistance and attach to the other end a carbon stick of suitable length and diameter; place over the point of the safe to be attacked an oven in the form of a hollow box lined with fire clay or asbestos, and having a hole large enough to admit the carbon. Using a wooden or other insulating handle with which to manipulate it, approach the carbon to the safe and an arc of from 9,000° to 10,000° in temperature is created, whereby the metal of the safe is readily fused, and with a quickness which is astonishing a hole is made completely through the structure. The conditions to be met are a knowledge of the voltage and amperage delivered at the point where the connection with the mains is to be made and the interposition of that resistance which will reduce the voltage to about 60 and give an amperage of 150 or over. These conditions are not difficult to the electrician and with a little practice can be met by any intelligent person.

Lieut. Rodman's paper is illustrated by photographs showing how neatly holes may be bored into either the steel plate or the Corliss chilled iron safe by an electric arc. All the intelligent burglar now has to do, it appears, is to employ a consulting electric engineer with an elastic conscience, if such a one can be found, and proceed to open any safe to which he can have an hour's undisturbed access.

We trust that some enterprising burglar will take advantage of the advice so kindly given him by Lieut. Rodman. Then, after a few safes have been successfully looted with the aid of electricity, we have no doubt that a way will be found to circumvent the electrical burglar. Several ways of doing this suggest themselves. The old-fashioned shot-gun fired by a spring accidentally touched by the burglar is one of the ways. Any number of electric systems of protection may be devised, of which the innocent-looking suspended live telephone wire crossed on an arc lighting circuit is one. If the electricians, mechanics and gunnery experts fail in devising sufficient means of protection, we may still call in the chemist. He would line the inside walls of the safe with a chamber containing compressed carbonic oxide, sulphuretted hydrogen or some other deadly gas. Then, when the electric burglar has bored the hole into the safe, he would be overwhelmed by a flow of poisonous gas sufficient to asphyxiate a regiment.

Since the above was put in type we have noted in several electrical journals that by electrical engineers generally the burglarizing of safes by means of electricity is not considered feasible.

Mr. E. G. Noe, superintendent of the engineering department of the General Electric Co., at Chicago, in a letter published in the "Electrical Engineer," states that the electric current needed to perforate a safe would be from 300 to 700 amperes at a

pressure of from 30 to 50 volts. If 350 amperes and 40 volts were required, it would equal practically 19 HP. To obtain this current from an alternating current of 1,000 to 2,000 volts, would require a specially designed transformer, which would weigh about 1,300 lbs.—rather an inconvenient tool for the average burglar to carry about. The conducting wires from the transformer would need to be almost half an inch in diameter. The current would make such a tremendous arc that it would hardly be safe to handle it. The fusing of the carbon and the metal would generate so much gas and smoke that it would be impossible for an operator to remain in a close room or vault to perform his work. Numerous other difficulties would be met with, so that the day of the practical application of electricity to safe burglarizing is probably far distant.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Street Improvements.

The failure of the superintendent of streets of a municipal corporation to record a contract for a street improvement at a proper time (where such recordation is required by law) does not affect the right of the contractor to enforce the lien of a street assessment levied to pay the contract price.—Wells v. Wood (Supreme Ct. Cal.) 46 Pacific Reporter, 96.

Letting Contracts to Lowest Bidders Discretionary Power.

The duty of public officers intrusted with the letting of contracts to the lowest responsible bidders is not merely a ministerial one, but they must carefully consider the terms of each bid, and their judgment in letting a contract cannot be controlled by a writ of mandamus. The discretion rests with the officials and not with the court, which has no authority to command them to award contracts to any particular bidder.—In re McCain (Supreme Ct. S. D.) 68 Northwestern Reporter, 163.

What Is Not Evidence of Survey.

The voluntary affidavit of a county surveyor, acting unofficially, as to the location of lines of old surveys, filed in the general land office, does not become an archive, so that it can be authenticated by the commissioner, thus become admissible as declarations of such party when he shall have died.—Daniels v. Fitzhugh (Ct. Civ. App. Tex.) 35 S. W. Rep. 38.

One Company Cannot Use the Tracks of Another Without Consent.

The Supreme Court of New York County, recently held that, where one company wished to connect with its other line by using a portion of the tracks of another company, such action would constitute a public nuisance, as well as an invasion of the rights of the other company; that under the laws of that state one company cannot construct a railway in the same street where the tracks of another are located without obtaining the consent of such other company.—Cent. Crosstown R. Co. v. Met. St. Ry. Co. (40 N. Y. Supp. Rep., 1095.

Defective Electric Wires Used by Street Railway Company.

Where a horse, on stepping on the rail of a street railway company's electric car track, received a fatal shock, the Supreme Court, Appellate Div. of New York, held that the mere happening of such an accident is sufficient to raise a presumption of negligence on the part of the railway company. The court said: The company had established and was operating a railway which employed electricity in wires over the street and in rails upon its surface. Here were sources from which, or agencies by which, the electric current could be generated, under such conditions, and with such direction and force, as to be capable of killing a horse traveling along the roadbed, and touching one of the rails with its foot. It is true, the expert testimony indicated that such an accident could not occur unless, through the defective insulation of the overhead wires, some portion of the positive current was withdrawn therefrom, and found its way to the ground or other surface upon which the animal was stepping at the time he also came into contact with the negative rail; but the very accident itself tended to show that such defective insulation existed, or some other condition which have produced the same result. The fact that the company brought the electricity into the street and that it was capable of thus escaping is sufficient to warrant the conclusion that the accident was the result of its doing so.—Clarke v. Nassau Elec. R. Co., 40 N. Y. Supp. Reporter, 78.

Power of City to Limit Charges for Gas.

Where a company is incorporated, either by a special act, or under the general laws of a state, with the power to manufacture and sell gas the power to charge and collect reasonable rates for the gas manufactured is implied, and forms a part of its contract with the state. And an ordinance of a city regulating the exercise of such franchise within its limits, adopted in pursuance of authority delegated by the legislature of the state, is the act of the state, and if in excess of its power to regulate or modify such franchise, is void, as impairing the obligation of a contract.—Capital City Gas-Light Co. v. Des Moines (U. S. Circuit Court, Dist. Iowa) 72 Federal Reporter, 829.

Contracts for Public Improvements.

The United States Circuit Court of District of Oregon says: One bidding for a contract to be let by a city is under no obligation to give the city the benefit of his knowledge acquired at his own expense by obtaining estimates of competent engineers as to the cost of constructing the proposed work, even if the means of such knowledge is not within the reach of the city.—McMullen v. Hoffman, 75 Federal Reporter, 547.

THE THEORY OF THE IDEAL COLUMN.*

Preface.

As the result of long study, the writer has become convinced of the following facts:

1. That the ordinary assumptions of flexure when applied to a straight, centrally loaded column, inevitably lead to the theory of the ideal column, as set forth in the analysis presented in the following paper.

2. That the phenomena exhibited by actual columns are very different from the deductions from the conditions assumed.

3. That when the assumptions are modified to conform to the actual conditions which exist in practice, say, for instance, by assuming eccentricity, transverse loading, friction on pins, etc., that the analysis, though complicated, satisfactorily accounts for most of the important phenomena which columns exhibit.

4. That much of the false theory regarding columns has its origin in attempts, foredoomed to failure, to account for the actual phenomena exhibited, by reasoning based on the assumption of purely ideal conditions.

5. That most engineers have but an imperfect conception of the significance of Euler's formula, and that there exists among a considerable number a belief that in its development the effect of direct compression has been so neglected as to vitiate the conclusions to which it leads.

In view of these facts it was thought that an analysis of the theory resulting from the application of the ordinary assumptions of flexure to the case of straight columns, with constant cross-section, centrally loaded, while being substantially a repetition of what has often been stated before, might, notwithstanding, make for sound knowledge.

In making the analysis it was deemed best that there should be no doubt as to direct compression having been properly considered, and therefore not only compression meaning internal stress, but compression meaning the shortening due to internal stress is taken into account. This leads to a refinement in the formulas derived, which would be absurd if the direct object of the analysis was the derivation of formulas for practical use, but which is desirable when the chief object in view is to show that the difference between the observed phenomena of actual columns and the deductions from ideal conditions must be attributed to the failure in actual practice to realize the conditions assumed and not to any error or omission in the argument.

It should be stated that equations (14), (15) and (16) appeared in an article by Prof. Mansfield Merriman in the "Journal of the Franklin Institute," January, 1882.

The writer wishes to thank Prof. A. J. Du Bois, Prof. J. B. Johnson and Prof. Mansfield Merriman for reviewing and correcting his manuscript and making valuable suggestions.

Henry S. Prichard, M. Am. Soc. C. E.
Trenton, N. J., Nov. 18, 1896.

The conditions requisite for an ideal column are that it shall be made of elastic material having a constant modulus of elasticity, shall have constant cross-section, shall have in its free state a straight axis, and shall be so loaded that before deflection takes place the line of thrust will coincide with the axis.

In such a column the stress before deflection will be wholly direct, and after deflection the column will only have, in addition to the direct stress, the flexure stress caused by the bending moment due to the deflected state of the column. A knowledge of the laws of deflection is therefore necessary to an understanding of the theory.

The general equation for deflection is

$$\triangle = \frac{M l^2}{C E I} \qquad (1)$$

in which

$\triangle$ = the deflection,
M = the maximum bending moment,
I = the moment of inertia about the center of gravity of the cross-section,
E = the modulus of elasticity,
C = a constant factor depending on the distribution of the load and end conditions, and
l = the length.

In trying to apply this well-known equation to columns, the difficulty is encountered that the length of a column in its compressed state is less than in its free state. In appendix A it is shown, first, that this difficulty can be overcome by letting l equal the length in the free state of the column, l_1 equal the length in the compressed state, and substituting $l\,l_1$ for l^2; second, that for a column with frictionless hinged ends, C equals π^2.

With these modifications the equation becomes

$$\triangle = \frac{M\,l\,l_1}{\pi^2 E I} \qquad (2)$$

Both equations (1) and (2) are derived on the assumption (a) that the deflection is so small that the length of the arc formed by the axis of the deflected column does not differ sensibly from that of its chord, an assumption, which for the kinds of material and lengths of columns used in construction, is closely approximated.

If the axis of the column coincides exactly with the line of thrust; that is, if there is not even an infinitely small variation between them, the column will remain straight under any load, and there will be no deflection, but if a small deflection is forcibly produced, say, for instance, by a lateral pressure, the column will, on the removal of this lateral pressure, if the load just equals a certain amount, be held in equilibrium in this deflected condition.

Let

P = this load; that is, the load which will just hold the column in equilibrium when in a deflected condition, and
A = the area of the cross-section,
r = the radius of gyration,

To determine the value of P let Fig. 1 represent a column held in equilibrium when in a deflected condition by a pair of forces, each of magnitude P, and conceive the column as divided into two parts by a transverse plane at the center C, then either part, A C, for example will be held in equilibrium by the external force P, and the internal stress acting on the cross-section at C.

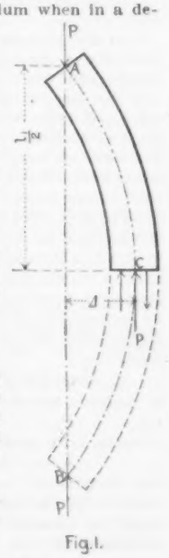


Fig. 1.

The internal stress can be resolved into a single force, applied at the axis and termed direct compression, and a couple known as the resisting moment.

The direct compression at C is equal and opposite to the load at A, and together with it, forms a couple, known as the bending moment, equal and opposite to the resisting moment.

The amount of this moment is P $\triangle$, which, being substituted in equation (2), gives

$$\triangle = \frac{P \triangle l\,l_1}{\pi^2 E I} \qquad (3)$$

$$P \triangle = \triangle \frac{\pi^2 E I}{l\,l_1} \qquad (4)$$

$$P = \frac{\pi^2 E I}{l\,l_1} \qquad (5)$$

From the theory of elasticity,

$$l_1 = l\left(1 - \frac{P}{A E}\right) \qquad (6)$$

* Since the paper was written the author has learned, through the kindness of Professor Merriman, that the modification of Euler's formula has been previously given by Winkler and Grasshof.

and from the theory of flexure,

$$r^2 = \frac{I}{A},$$

which, being substituted in equation (5), results in

$$\frac{P}{A} = \frac{\pi^2 E r^2}{l^2} + \frac{P^2}{A^2 E} = \frac{E}{2} - \sqrt{\frac{E^2}{4} - \frac{\pi^2 r^2 E^2}{l^2}} \quad (7)$$

$$\frac{l}{r} = \sqrt{\frac{\pi^2 E}{\frac{P}{A} - \frac{P^2}{A^2 E}}} \quad (8)$$

Equation (7) differs from Euler's formula only by the term $\frac{P^2}{A^2 E}$, which, within the limits imposed by the properties of the materials of which columns are made, is so small that in the practical application of the formula it can be neglected for the sake of simplicity. It should be understood, however, that the equation in its simplified form, that is, Euler's formula, is not an absolutely correct deduction from the premises previously stated. While it has been frequently claimed that Euler's formula is not absolutely correct, the writer has no knowledeg of the correction of its error having been previously made, but is desirous of obtaining information on this point.

From an examination of the equations (3) to (8) inclusive, the following conclusions can be drawn:

1. From equation (4) it is evident that the deflection is a factor of both the bending moment, $P \triangle$, and the resisting moment,

$$\triangle \frac{\pi_2 E I}{l\ l_1},$$

and may therefore be of any amount within the limits of assumption (a); that is, practically, it may be any deflection that can occur in a column strained within the elastic limit, without altering the value of the load, P, necessary to hold the column in equilibrium in its deflected condition.

2. If the load on the column is less than P, there can be no deflection, and the stress will be wholly direct.

3. If the load on the column is slightly greater than P, and the slightest conceivable variation exists between the position of the axis of the column and the line of thrust, then a deflection will be produced which will continue to grow until failure occurs, without developing a resistance equal to the load. It may happen that some of the columns encountered in practice are of such length that before failure occurs the deflection will become so great that the difference in length between the arc and its chord (see assumption a) cannot be practicably neglected, but when this happens, part of the material in the column will have been strained beyond the elastic limit, thereby lessening its resilience to an extent which more than offsets any possible increase in resistance from the large deflection.

4. If the length is such that the load, P, required to maintain any deflection, produces a direct compression, $\frac{P}{A}$, greater than the elastic limit, S_e, then failure will begin, without any preliminary bending, by the destruction of the elastic properties of the material under the action of direct compression alone. On the other hand, if the length is such that the direct compression, $\frac{P}{A}$, is less than S_e, then failure will occur from the bending of the column.

Between the two foregoing conditions of length there will be a dividing line below which failure will begin from direct compression without any bending, and above which failure will occur by bending.

For the $\frac{l}{r}$ which marks this dividing line $\frac{P}{A} = S_e$, which being substituted in equation (8) gives

$$\sqrt{\frac{\pi^2 E}{S_e - \frac{S_e^2}{E}}}, \text{ or practically } \sqrt{\frac{\pi^2 E}{S_e}},$$

as the value of the particular $\frac{l}{r}$ in question.

The foregoing formulas and conclusions have been deduced from an analysis of ideal columns with two-hinged ends, but by substituting n for π it can be applied to ideal columns with other end conditions.

When an ideal column has one free end and one fixed end, $n = 0.5\ \pi$, both ends hinged $n = \pi$, one end hinged and one end fixed $n = 1.5\ \pi$, both ends fixed $n = 2\ \pi$. For a demonstration of these valuations see Appendix B.

The preceding conclusions regarding ideal columns are not new, except possibly as regards the modification of Euler's formula, but have been stated by a number of writers, among whom may be mentioned Thomas Claxton Fidler, M. Inst. C. E., who has given the theory in a paper on the "Practical Strength of Columns," delivered before the Institution of Civil Engineers' Session, 1885-86, in which he has also clearly shown that a slight departure from the ideal conditions assumed makes a decided difference in the behavior of a column.

The effect of the difference between ideal conditions and those which are liable to be encountered is so great that the theory of the ideal column should not be applied without modifications to practical column design.

If the theory is not new and is not strictly applicable to actual columns, the question may be asked: "Why is it made the subject of this paper?" The reply is that it is generally either misunderstood or not accepted, and much effort that is worse than useless is frequently expended in trying to deduce the various existing formulas, and likewise new ones from purely ideal conditions.

This has been strikingly illustrated in regard to the common-column formula, variously known as the Tredgold, Gordon and Rankine formula, which is largely held as a theoretically correct deduction from ideal conditions in all but the constant. As this formula is a good practical one, and extensively used, it is desirable that its theoretical status and the reasons for its practical value should be understood.

Let W be the least load which will produce the limiting stress S_e in any part of the column.

Part of the stress S_e will be the direct compression; that is $\frac{W}{A}$, and the remainder, when there is any, the flexure stress; that is $S_e - \frac{W}{A}$. Let

V = the distance from the center of gravity to the extreme fiber on the concave side of the column.

From the theory of flexure

$$S_e - \frac{W}{A} = \frac{W \ldots V}{A\ r^2} \quad (9)$$

$$\frac{W}{A}\left(\frac{\triangle V}{r^2} + 1\right) = S_e \quad (10)$$

$$\frac{W}{A} = \frac{S_e}{1 + \frac{\triangle V}{r^2}} \quad (11)$$

If the value of $\triangle$ is taken from equation (2) and l^2 is substituted for $l_1\ l$ (which can be done without practical error),

$$\frac{W}{A} = \frac{S_e}{1 + \frac{M\ l^2\ V}{\pi^2\ E\ I\ r^2}} \quad (12)$$

From the theory of flexure

$$M = \frac{I\left(S_e - \frac{W}{A}\right)}{V} \quad (13)$$

which being substituted in (12) gives

$$\frac{W}{A} = \frac{S_e}{S_e - \frac{W}{A}} \quad (14)$$

$$1 + \frac{\pi^2 E}{\frac{l^2}{r^2}}$$

By reduction

$$\frac{W}{A} = \frac{S_e}{2} + \frac{\pi^2 E r^2}{2 l^2} \pm \left(\frac{S_e}{2} - \frac{\pi^2 E r^2}{2 l^2}\right) \quad (15)$$

$$\frac{W}{A} = S_e \text{ or } \frac{\pi^2 E r^2}{l^2} \quad (16)$$

which corresponds as it should with the conclusions previously reached.

If, however, instead of giving to $\triangle$ its true value, it is given a value corresponding to the assumption that the stress S_e is due entirely to flexure, as is the case with beams which are subjected only to transverse loads, then, as for this assumption

$$M = \frac{I\ S_e}{V} \quad (17)$$

from (2) and (17)

$$\triangle = \frac{S_e\ l^2}{\pi^2\ E\ V} \quad (18)$$

which being substituted in equation (11), gives the common column formula,

$$\frac{W}{A} = \frac{S_e}{1 + \frac{S_e\ l^2}{\pi^2\ E\ r^2}} \quad (19)$$

with $\frac{S_e}{\pi^2 E}$ in the place of the usual empirical coefficient, a substitution recommended by the late Mr. John D. Crehore, Prof. Mansfield Merriman and Prof. A. J. Du Bois.

From the equation (18) it will be noticed that, for the stress S_e, the deflection is taken as directly proportional to the square of the length and inversely proportional to the lateral dimensions (thus assuming that the stress S_e is due entirely to flexure), which is precisely the error made by Professor Rankine (see "Applied Mechanics," page 300). A comparison of equation (19) with the correct equation (14) shows that for both equations the value of $\frac{W}{A}$ is S_e, for $\frac{l}{r} = 0$, and zero for $\frac{l}{r} = \infty$, and that between these extremes equation (19) gives smaller values for $\frac{W}{A}$ than the correct equation (14).

This relation is shown graphically by Fig. 2.

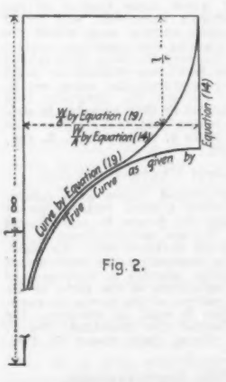


Fig. 2.

As the assumptions on which the theory of the ideal column depends are never entirely realized in practice, it happens that the results of experiments correspond better with equation (19) than with equation (14), and make the former (19) of great practical value as a failure formula for columns with hinged ends.

By substituting n for π it becomes general as regards end conditions.

For one fixed and one free end the theoretical value of $n = 0.5\ \pi$ can be used.

For frictionless hinged ends, which are closely approximately by the round ends used in experiments, $n =$

Columns with the ordinary pin ends of practice,

when free from eccentricity and transverse loading, have their ends partially fixed by friction, and it is customary to assign to "n" a larger value in consequence, but as it can be demonstrated both theoretically and by experiment that a slight eccentricity can offset the friction, a larger value for n is not recommended.

For absolutely fixed ends $n = 2\ \pi$, but as such ends are never entirely realized, even in careful experiments, it is recommended that the value of n should not be considered as greater than $1.5\ \pi$ and should be considered as less on occasion.

Correspondingly for columns with one hinged and one fixed end, n should not be considered as having a greater value than $1.25\ \pi$.

While the variation in the results given by the common formula, when arranged as described, from those given by the theory of the ideal column affords a good guide as to the limit of variation to be expected under the ordinary imperfect conditions, the formula is in no sense the result of an analysis of such conditions.

A study of the effects of the various departures from ideal conditions is desirable as it is in this field that increased knowledge of the behavior of columns can be reasonably expected. There have already been some very instructive investigations in this direction, such, for instance, as the Pencoyd experiments on eccentrically loaded columns, described in Mr. James Christie's paper before the American Society of Civil Engineers, "Transactions," 1884; Mr. Thomas Claxton Fidler's analysis of the effect of a variation in the modulus of elasticity in the paper previously referred to, and Prof. J. B. Johnson's analysis of combined direct and bending stresses in "Modern Framed Structures."

APPENDIX A.

Demonstration of the Equation for the Deflection of an Ideal Column with Hinged Ends

$$\triangle = \frac{M\ l\ l_1}{\pi^2\ E\ I}$$

Conceive the column shown by Fig. 1. as divided into such a large number, N, of equal parts that the radius of curvature, ρ, of the axis of the column, is sensibly constant for the entire length of each part. Each part is bounded by transverse planes parallel before the deflection of the column and radial after.

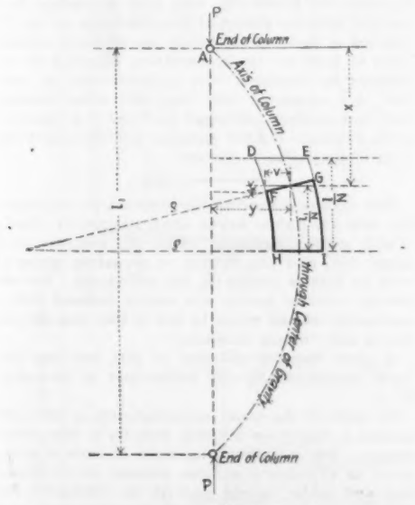


Fig. 3.

Let D, E, H, I (Fig. 3), represent any one of these parts in its original state before the deflection of the column, and F, G, H, I, the same part in its strained state after deflection.

Then the line D F represents the shortening of the extreme fiber on the concave side. Part of this shortening is caused by the uniformly distributed direct compression, and the remainder, K, by the flexure stress.

Let M_x equal the bending moment at any point.

From similar triangles

$$\rho : \frac{l_1}{N} :: V : K \qquad (1a)$$

$$\rho = \frac{l_1\ V}{N\ K} \qquad (2a)$$

From the theory of flexure

$$K = \frac{M_x\ V\ l}{E\ I\ N} \qquad (3a)$$

$$\rho = \frac{E\ I}{M_x} \times \frac{l_1}{l}. \qquad (4a)$$

The value of the radius of curvature in terms of the co-ordinates x and y is given by the equation

$$\rho = -\frac{d\ x^2}{d^2\ y} \qquad (5a)$$

$$-\frac{d^2\ y}{d\ x^2} = \frac{M_x\ l}{E\ I\ l_1} \qquad (6a)$$

Since M_x equals P y, multiplying each side of this equation by 2 d y, when x is the independent variable and integrating once, gives

$$\left(\frac{d\ y}{d\ x}\right)^2 = -\frac{P\ l}{E\ I\ l_1}\ (y^2 + c) \qquad (7a)$$

When $\frac{d\ y}{d\ x} = 0$, $y = \triangle$, = deflection at the center; therefore $c = -\triangle^2$,

$$\text{and } \left(\frac{d\ y}{d\ x}\right)^2 = \frac{P\ l}{E\ I\ l_1}\left(\triangle^2 - y^2\right)$$

$$\text{or } d\ x = \sqrt{\frac{E\ I\ l_1}{P\ l}} \cdot \frac{d\ y}{\sqrt{\triangle^2 - y^2}} \qquad (8a)$$

$$\text{Whence } x = \sqrt{\frac{E\ I\ l_1}{P\ l}} \cdot \text{arc Sin} \frac{y}{\triangle} + c \qquad (9a)$$

When $x = 0$, $y = 0$ $\therefore c = 0$,

$$\text{or } x \sqrt{\frac{P\ l}{E\ I\ l_1}} = \text{arc Sin} \frac{y}{\triangle} \qquad (10a)$$

$$\text{Therefore } y = \triangle \text{ Sin } x \sqrt{\frac{P\ l}{E\ I\ l_1}} \qquad (11a)$$

This is the equation of the elastic line, the curve being a sinusoid. For

$$x = \frac{l_1}{2},\ y = \triangle, \text{ and } P = \frac{M}{\triangle}$$

(M representing the maximum moment P $\triangle$) therefore substituting these values in (10a),

$$\frac{l_1}{2} \sqrt{\frac{M\ l}{\triangle E\ l\ l_1}} = \frac{\pi}{2} \qquad (12a)$$

$$\triangle = \frac{M\ l\ l_1}{\pi^2\ E\ I} \qquad \text{Q. E. D.}$$

APPENDIX B.

Analysis of the Effect of Various End Conditions on the Resistance of an Ideal Column to Bending.

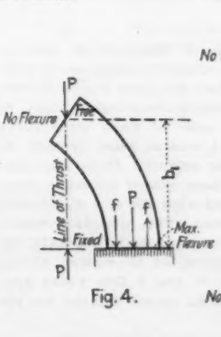


Fig. 4.

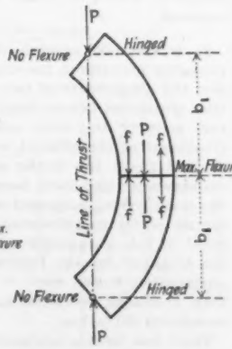


Fig. 5.

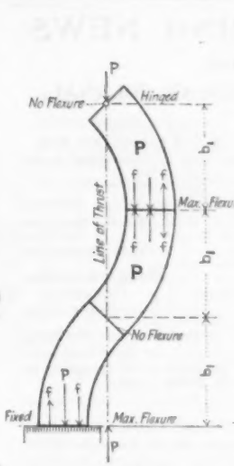


Fig. 6.

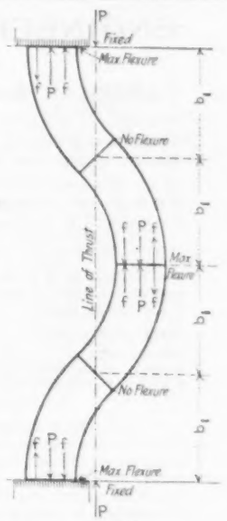


Fig. 7.

Let Figs. 4, 5, 6 and 7, represent columns having respectively the various end conditions under consideration.

Conceive these columns as deflected in the manner indicated and divided into elements by cross sections passed through at the points of maximum and minimum flexure stress. As regards the forces that act on them, each of these elements can be represented by Fig. 8, which is simply one-half of a column with two hinged ends deflected in a simple curve.

Substituting 2 b for l in equation (8) gives

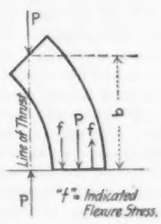


Fig. 8.

$$b = \frac{r}{2}\sqrt{\frac{\pi^2\ E}{\frac{P}{A} - \frac{P^2}{A^2\ E}}} \qquad (1b)$$

It is evident from this equation that as the force P must be the same for each of the elements composing the same column, that all of those elements must have the same compressed length b_1, and the same original length b.

As P is a minimum when b is a maximum, it is also evident that the form of curve which requires the least load to maintain a deflection is that which divides the column into the least number of elements.

The values of b which meet this requirement for the end conditions under consideration, are

l, $\frac{l}{2}$, $\frac{l}{3}$ and $\frac{l}{4}$, respectively.

Successively substituting these values of b in equation (1 b) and transposing, results as follows:

For columns with one end free and one end fixed

$$P = \frac{\left(\frac{\pi}{2}\right)^2 E\ r^2}{l^2} + \frac{P^2}{A^2\ E} \qquad (2b)$$

For columns with both ends hinged

$$P = \frac{\left(\frac{2\ \pi}{2}\right)^2 E\ r^2}{l^2} + \frac{P^2}{A^2\ E} \qquad (3b)$$

For columns with one end hinged and one end fixed

$$P = \frac{\left(\frac{3\ \pi}{2}\right)^2 E\ r^2}{l^2} + \frac{P^2}{A^2\ E} \qquad (4b)$$

For columns with both ends fixed

$$P = \frac{\left(\frac{4\ \pi}{2}\right)^2 E\ r^2}{l^2} + \frac{P^2}{A^2\ E} \qquad (5b)$$

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In our issue of Aug. 22, 1895, we published an article on the "Formulas of Long Columns," by Prof. A. J. Du Bois. This paper called out considerable criticism, and, prior to its publication, some attempt was made to carry on a discussion by correspondence between the parties interested, and have them reach substantial agreement upon the points in controversy before publishing the matter. It must be confessed, however, that this attempt accomplished little, and the symposium on this subject, which was finally published in our issue of Oct. 3, 1895, contributed to by Professors Johnson and Du Bois and Mr. Henry S. Prichard, was chiefly remarkable as showing how widely it was possible for men standing high as authorities to differ in their views, even upon questions of mathematics, where the truth or falsity of a proposition ought to be susceptible of positive truth.

After this publication was made, Mr. Henry S. Prichard, Chief Engineer of the New Jersey Steel & Iron Co., undertook the task of bringing about an agreement between the above authorities upon the points in dispute, and was thus led to the preparation of the paper which is published elsewhere in this issue. In our next issue we shall give some careful criticisms, which have been made upon this paper by Professors Johnson, Merriman and Du Bois, with an "author's closure" by Mr. Prichard. We will merely say at this time that all of these well-known authorities appear to be well satisfied of the soundness of Mr. Prichard's discussion, and show a harmony which is exceedingly gratifying.

For the benefit of those of our readers to whom Mr. Prichard's discussion is "all Greek," and yet who may wish to keep posted on the best practice in column computations, we would say that as we understand the matter, Mr. Prichard's paper is not a criticism of the columns or column formulas in practical use. The value of Mr. Prichard's paper is this. Every little while some engineer gets into his head that the use of column formulas, based only on experiments, is all wrong, and that by a rational column formula, or one based on the theory of column stresses, it would be possible to compute much more accurately than at present the strength of a column. There is a never-ceasing crop of engineers who attempt just this thing. Now, for the benefit of such engineers, Mr. Prichard has showed just what must be done to develop a "rational" or "ideal" column formula, and then concludes that such a formula would be no better or safer for computing actual columns, which differ widely from the mathematical conception of a column, than the ordinary empirical formulas now in use.

Two important principles relating to sewage purification are emphasized by the recent report of Mr. Samuel M. Gray, M. Am. Soc. C. E., and Dr. Thos. M. Drown, on the sewer system of Worcester, regarding which a note was published in our issue of April 29. These are, first, that where the sewage of a city is to be purified, the separate system of sewerage should be adopted, if practicable, and, second, that chemical precipitation at its best affords only a partial purification of sewage.

The city of Worcester was already provided with the combined system of sewerage when a legislative act was passed compelling it to purify its sewage before discharging it into the Blackstone River. It has recognized the disadvantages of the combined system in connection with its purification works, and in late years has made some or all of its sewer extensions on the separate plan. The amount of storm water reaching the disposal works at Worcester has not been limited by that collected by the sewers, but has been augmented by the flow from the drainage area of Mill Brook, above the point where the brook has been converted into an outlet sewer. There has been much talk, in the past, of separating the waters of Mill Brook from the sewage, and this is what the experts recommend as the first step, to be followed later by the construction of new sanitary sewers throughout the city, leaving the present combined sewers to be used for storm water only.

But while the separation of Mill Brook from the sewage has been strongly urged in the past, and a complete separate system of sewerage has been talked of, sometimes seriously, little has been said regarding the advisability of supplementing chemical precipitation by some other process. As it is, the report only recommends experiments with intermittent filtration, suggesting that ten acres of filter beds be prepared, which would place the experiments on a basis thoroughly comparable with actual practice. The matter is put in this tentative way because there is a difference of opinion regarding the degree of purification necessary, the problem being complicated by the fact that the bottoms of the Blackstone River, and of the millponds on it, are covered with organic matter deposited before the precipitation works were put in operation, and during heavy storms since then, when it has been impossible to treat all the sewage. These deposits, it is alleged, are to a large degree responsible for recent complaints regarding the offensive condition of the river. With the exclusion of all the sewage from the river chemical precipitation might suffice, but meanwhile studies could be made of the possibilities of supplementing precipitation with filtration. The two might be found to work together advantageously, in any event.

The Worcester works are now removing a little more than half of the organic matter in the sewage, and nearly all of the suspended matter, but the remaining half of the organic matter, in connection with the lime in the effluent, might give trouble at these or any other works, under certain conditions, such as too low dilution, reaches of stagnant water, or banks alternately covered and exposed.

It is common enough in England—in fact, it probably prevails in the majority of cases—to subject the effluents from precipitation works to further treatment before finally discharging them. In this country the only case of such subsequent treatment of the effluent was at East Orange, N. J., and there the works suffered from improper management and have been closed for some time, the town having arranged with the city of Newark for an outlet to tidewater. The preceding statement in this paragraph relates to city plants. At the Hospital for the Insane, at Rochester, Minn., purification works were in use a few years ago, with chemical precipitation supplemented by intermittent filtration.

There has been a tendency in this country, more especially among laymen, to consider chemical precipitation as a complete process, wholly comparable in results with intermittent filtration, or broad irrigation. This is, of course, wholly wrong. Chemical precipitation may often effect as high a degree of purification as local conditions demand; but it cannot compare for thoroughness with intermittent filtration. Where land or labor, or both, are dear, chemical precipitation might often be used to remove a part of the organic matter, making a higher rate of land filtration possible, decreasing the labor required to scrape the beds and renew the sand, and thus lessening the cost of filtration, and possibly of the whole cost of purification.

As to excluding storm water from sewage which is to be purified, it is obvious its volume is so far in excess of the sewage proper that in times of heavy rain a thorough purification of the flow from a combined sewerage system is entirely out of the question. This has always been recognized in this country where sewage purification has been under consideration for towns not yet provided with sewerage systems, but there are some cities with combined systems, which, like Worcester, may yet be compelled to purify their sewage. Before deciding on any plan they will do well to consider most carefully whether a separate system of sewerage is not the first thing to be provided. For towns without sewerage facilities, the separate system is now firmly established as the proper one to adopt in nearly all cases, without regard to the question of purification. We do not now remember of a single town in the United States or Canada that has established a combined system of sewerage in the past five years, and many cities where the combined system was put in years ago are building extensions on the separate plan, wherever possible.

Since writing the above, an examination of the "Report of the City Engineer to the City Council in relation to the disposal of the sewage of the City of Worcester," made by Mr. Chas. A. Allen, M. Am. Soc. C. E., in 1886, shows that Mr. Jas. Mansergh, M. Inst. C. E., of London, in a letter to Mr. Allen, pointed out the probable necessity of excluding the natural waters of Mill Brook from the sewerage system, and of making other changes in the system to exclude storm water; and that Mr. Allen included in his report an estimate for diverting Mill Brook from the sewage (not the sewage from Mill Brook, as now recommended), but advised that this and other changes of the sort be deferred. Also that Prof. Leonard P. Kinnicutt, who was intimately connected with the chemical investigations at the inception of the disposal works, advised that a small area of land for the intermittent filtration of the effluent be provided "for possible use in very hot, dry weather;" but that Mr. Allen thought this unnecessary, although he located a filtration area available for the purpose and estimated the cost of preparing it for use.

The expenses incurred by contractors in preparing bids for public works often amount to considerable sums, especially when the contract is a large one, and the burden of preparing plans as well as bids is placed on the contractor. The ordinary rules of justice and equity demand that a contractor should never be put to this expense unless a city "means business."

A most flagrant violation of this rule has just been committed by the authorities of Hoboken, N. J.

On April 8, the water commissioners of that city passed a resolution inviting bids for a new water supply. The specifications were of such a character as to demand a large amount of investigation and outlay on the part of the contractor before an intelligent bid could be submitted, and only three weeks were given for this purpose. We are informed that several large contracting firms, accepting the city's invitation in good faith, went to no small expense and trouble in preparing plans, estimates, etc., preparatory to submitting bids. But on April 26, only four days before the date set for opening the bids, the commissioners rescinded their resolution calling for bids, and passed another making a new contract with the corporation which now furnishes the water supply, the Hackensack Water Co., for 25 years. Such a course seems absolutely unjustifiable under any ordinary cir-

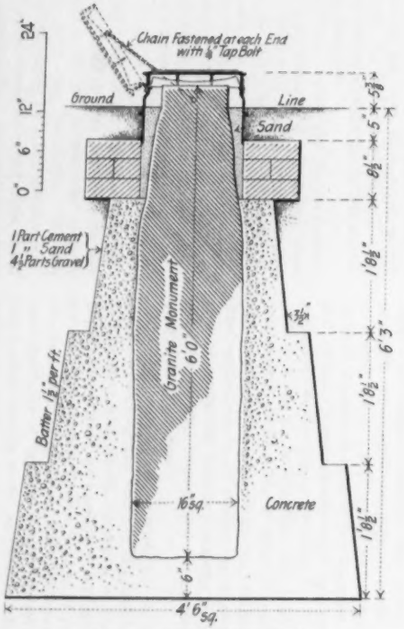


FIG. 2. MONUMENT FOR STANDARDIZING TAPES.

FIG. 3. DETAILS OF BOX ENCLOSING TOP OF MONUMENT FOR STANDARDIZING TAPES.

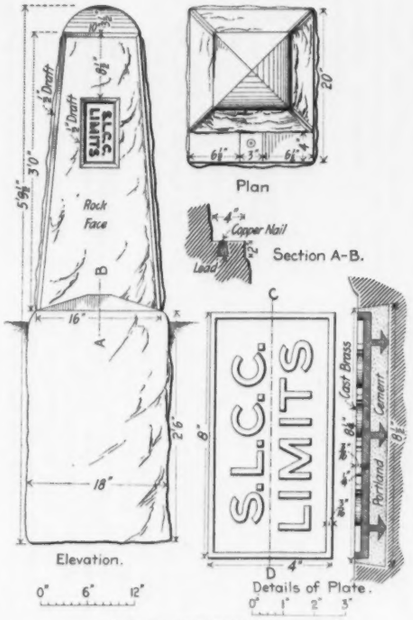


FIG. 8. MONUMENT FOR CITY LIMITS.

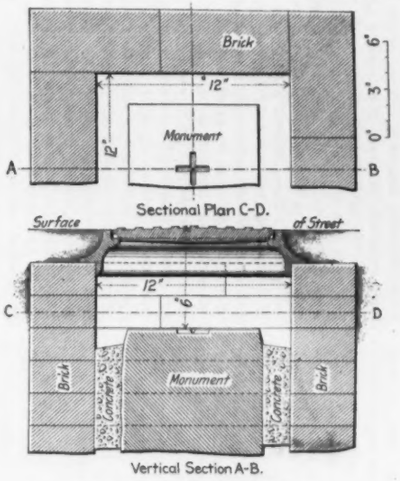


FIG. 1. STREET MONUMENT.

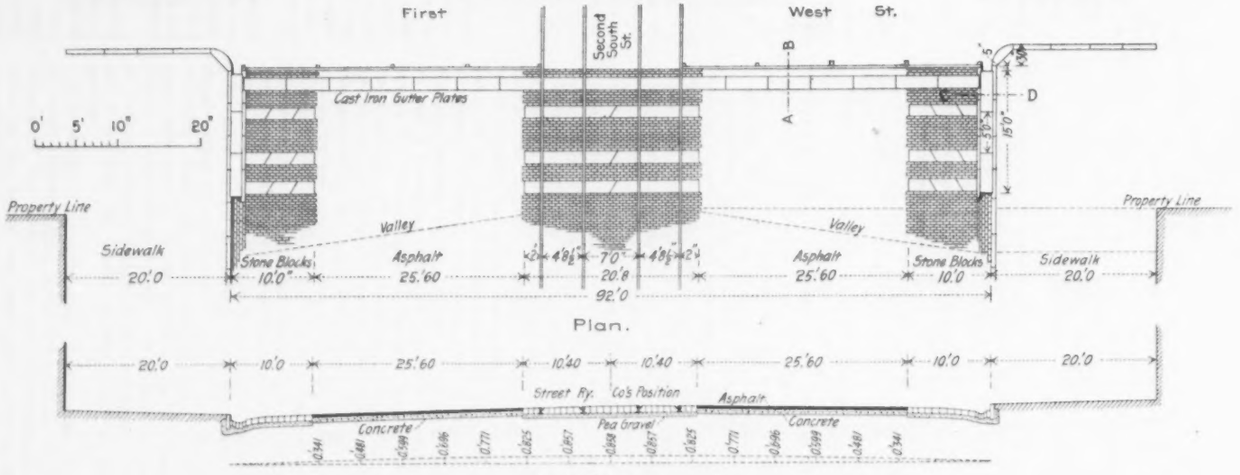


FIG. 9. DETAILS OF STREET WORK.

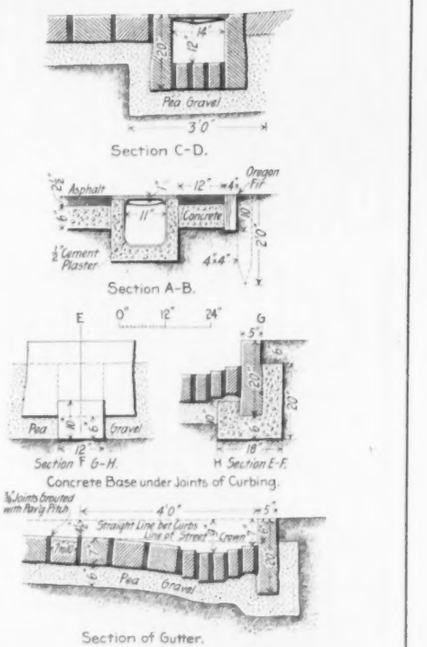


FIG. 10. CONDUITS AND GUTTERS FOR IRRIGATION WATER IN STREETS.

MUNICIPAL ENGINEERING WORKS IN SALT LAKE CITY.

cumstances, and the only excuse for it which we have seen offered by the Hoboken commissioners was that the Hackensack company declared that its offer of 10 per cent. reduction in the present water rates would be withdrawn if not accepted before April 30, the day set for receiving bids. One contractor was present at the meeting noted above, and submitted a protest against the action taken, on the ground that he had proceeded in good faith to prepare bids under the call, and had notified the commissioners of the fact. We sincerely hope that the contractors who have thus expended time and money to no purpose will not rest content with a simple protest, but may pursue the matter in the courts. It is, we believe, a well-settled principle, that when a municipal corporation has publicly advertised for bids for certain work, it cannot legally award that work by private contract, without regard to the proposals which it has publicly invited. To make a contrary rule would be to open the door wide to corruption of the gravest sort. Besides this, it is in the interest of justice and equity that the rights of intending bidders should be upheld by the law. If cities can thus subject contractors to needless expense with impunity, it will not be long that they can induce reputable and responsible contractors to respond to their calls for proposals.

The report of the Commissioner of Wires of the City of Boston which has recently been issued discusses the troubles due to the presence of explosive gas in electrical subways in the city and reaches the remarkable conclusion that it is the business of the gas companies to keep the gas out of the electrical subways. We quote as follows from his report as published in the Boston "Advertiser" of April 26:

> Up to the present time the electric companies have not found it necessary to take any action to prevent the presence of gas in the electrical subways. It seems to me that that duty devolves upon the gas companies.
>
> Why should the gas companies permit their product to escape from their distribution pipes and allow it to enter these subways, thus converting them into a source of danger to men entering the manholes, people passing through the streets, and endangering the lives and property of the occupants of buildings?
>
> It is clear to me that these companies should confine their product within their distribution pipes until it reaches their customers; they should exercise the same control over their systems of distribution as the electric companies are obliged to do with theirs.
>
> I do not approve of the plan adopted in New York of forcing air into the subways at a sufficient pressure to keep the illuminating gas out, as it is attended with some danger, for a slight increase in this pressure would tend to force the gas into the buildings along the line of the electrical subways.
>
> The leakage of gas from the pipes into the soil, electrical subways and manholes should be stopped at these points by the gas companies, because that is the only true and safe remedy.

This is a novel way of regarding the problem of electrical subway ventilation, and we very much doubt whether the courts could be induced to adopt this view. Is a gas company bound absolutely to prevent leakage from its mains? If it is, it might as well go out of business, for absolutely to prevent leakage from a system of gas mains is an impossibility. Now the law requires no one to perform impossibilities, and if a gas company exercises the proper and usual precautions to prevent leakage upon its mains, it is satisfying the legal requirements. Whether it is responsible for any loss or damage which may be sustained on account of the gas which still escapes from its pipes notwithstanding its care, is a point which would be a good one for lawyers to dispute over. So far as we know, its responsibility to this extent has never been established.

As for the objection which the Commissioner raises to the New York system of ventilating electrical subways by blowers, we have never heard of any trouble with the entry of gas into buildings from this cause, and the blower system has now been in use in New York for a half dozen years. That it has effectually prevented the explosions in the subways which occurred prior to its introduction, is a matter of common knowledge.

When vitrified brick first came into use as a material for street paving, engineers and city officials were much puzzled over the conflicting reports which were given as to its durability. In one city all accounts would agree as to its perfect success. In another city it would be voted with equal unanimity a complete failure. The evident cause of this was a variation in the quality of the brick; and in order to be able to purchase supplies of brick in open competition, engineers were forced to devise a system of tests and specifications under which bids for brick or brick paving could be invited. In this work of formulating tests and specifications each city engineer, as a rule, carried out his own ideas, and the result was a very great variety in the tests and specifications which paving brick makers were required to meet. This formed, of course, a barrier to the ready comparison of results obtained in different cities, and prevented one engineer or city from readily gaining information from the results obtained by another. Another objection to this state of affairs was that in the preparation of specifications two opposite extremes were found. Some engineers, through inexperience or insufficient information, failed to prescribe such tests as would insure the selection of first-class material. Others required such a multiplicity of tests that the expense of testing was a serious matter, and brick were at times rejected on tests which actually gave little information as to the merit of the brick as a paving material.

The desirability of a standard specification for brick paving to form at least a general guide to engineers has long been evident, and a year ago the National Brick Manufacturers' Association appointed a committee to investigate and report upon methods of testing paving brick. On another page of this issue we give practically in full the report submitted by Prof. Edward Orton, Jr., of Ohio State University, Columbus, O., the secretary of this committee, at the annual convention of the association, which was held at Buffalo in February. From this report it will be seen that various conditions which might affect the value of tests were taken into consideration, and that tests were carried out under these various conditions so as practically to determine their influence upon results. After the tests had been made, and the results tabulated and digested, specifications were prepared for standard forms of tests, and these have been adopted by the association. These specifications are appended to Prof. Orton's report. While these specifications include four methods of tests (rattler, absorption, cross-breaking and crushing), the committee advised that the absorption test may be abandoned, as any paving brick that will satisfy the requirements of reasonable mechanical tests will not absorb sufficient water to prove injurious to it in service; and also recommended that crushing tests should be purely optional, as the experimental work indicated that it is not possible to show any close relationship between high compressive strength and the qualities necessary for a good paving material. These recommendations were adopted by the association, which thus practically adopted the standard rattler test and the standard cross-breaking test as sufficient for determining the qualities of the brick.

Of these two tests there is no question at all that the rattler test is by far the most important and valuable. A brick for street paving must be hard enough to stand wear, dense enough to exclude water and tough enough to resist fracture under the blows of traffic. The rattler test, when properly made, will fracture a brittle brick and will wear away a soft brick; and any brick which is hard enough to endure the abrasion in the rattler within proper limits will not absorb water enough to suffer injury by frost.

It is a highly interesting fact that the rattler test should prove to be of more practical value in this industry than the old tests of statical strength. The rattler test is, of course, an impact test, or a test of resilience, and our readers may recall our remarks on the importance of resilience tests a couple of years ago.

There is sometimes a tendency in engineering work to magnify the value of the standard tests of compressive and tensile strength, or the results of chemical analysis, as applied to all classes of materials. Experience in the testing of paving brick shows that it is at times wise to develop entirely new methods of testing to suit special materials, which shall imitate so far as possible the conditions under which the material has to do service.

THE FOREST RESERVATIONS OF THE UNITED STATES.

A timely pamphlet has been issued by Mr. B. E. Fernow, chairman of the executive committee of the American Forestry Association, explaining the objects and intentions of the projectors of forestry reservations in the United States. This statement is made to clear away popular misconceptions regarding these objects, and to meet the strong opposition to the project which has grown up in states where large areas have been withdrawn from public use. Government timber lands have been devastated by fire and by theft of lumber for many decades, through absence of any care over them and the lack of any rational system permitting the utilization of the wood upon them by the resident population. For twenty-five years past this deplorable condition of the public timber domain has been recognized by the heads of the Interior Department and the General Land Office, and legislative relief has long been sought in vain.

In 1887 the then Secretary of the American Forestry Association formulated and had introduced into the 50th Congress a bill, later known as the Paddock Bill, providing for the withdrawal of all timber lands on the public domain from entry or other disposal. Such land was set aside as public forest reservations, and a fully organized service was to be instituted, in the Department of the Interior, to take care of these reservations, protect them against fire and theft, regulate their occupancy by prospectors, miners and herders, and permit the cutting and sale of timber under a system of licenses and the application of rational forestry methods.

This bill did not become a law, but in its place an act was passed and was approved March 3, 1891, setting forth that the President of the United States

> may, from time to time, set apart and reserve in any state or territory having public lands bearing forests, wholly or in part covered with timber or undergrowth, whether of commercial value or not, public reservations, and the President shall, by public proclamation, declare the establishment of such reservations and the limits thereof.

Under this law President Harrison established 16 reservations and President Cleveland 1, aggregating in area 17,500,000 acres. But the total absence of specific legislation, relating to the care of this land, protection against fire and theft, legitimate use of timber and entry on these lands by authorized parties, completely nullified the intentions of the original projectors of forest reservations. The effect of the law of 1891 was to withdraw these reservations, not only from sale and entry, but from all use whatsoever; and under the terms of the law the Department of the Interior was powerless either to protect or utilize them.

The present opposition to public timber reservations can be traced directly to the working of this ill-devised act. The sudden withdrawal from use of vast areas of timber, some of these occupied by mining and lumbering industries, dependent upon wood supplies, has led to violent opposition to the law, and an effort to have these areas restored to the public domain. Under present conditions a mining company needing timber must either steal it, buy it of others who have stolen it, or obtain it by some circumvention of the law. The government land is now being systematically plundered by lumbering companies under a provision of the law permitting the single settler to cut timber intended for his own use free of charge, and thousands of men have been induced to perjure themselves so that a lumbering company may acquire the acreage sufficient for its purposes. In the absence of any rational system of forestry protection, fires range unchecked, and hundreds of square miles of forest lands have been thus devastated. Last, but not least, the scanty timber and undergrowth of the Southern Pacific Coast region is now being cut off. This forest, while of trifling value for timber, is of great importance for preserving the scanty water supply of this section.

It is evident, therefore, that the intention and purposes of the original projectors of forest reservations in this country are not only misunderstood by the public, but they have been wholly misconstrued by Congress, and the laws actually passed make past conditions worse and are themselves responsible for all the present opposition to

the establishment of forestry reservation. The real plans of the officials and individuals who have so long combated the waste of valuable wood material may be briefly set forth as follows: Withdraw from sale or entry all lands not fit or not needed for agricultural purposes, and make the lands at the headwaters of streams and on mountain slopes generally the objects of especial care by the government. Permit mining or other occupation, but place this occupation under regulations preventing unnecessary waste; and cut and sell timber under such rules as will secure perpetuation and renewal of forest growth. Provide for protection against fire, theft and unlawful occupation. Respect all existing vested rights, and arrange some system of exchange, if necessary, of private lands included in reservations. Finally, restore to the public domain for entry all lands on forest reservations which may be found suitable for agriculture.

These provisions, formulated into laws, would provide for the rational management of forest areas, for the future and the present; and as they would recognize the interests of all classes, they would undoubtedly meet with public approval. The so-called Paddock Bill, and the less elaborate McRae Bill, presented to the last Congress, embodied these business-like propositions, and a bill drawn upon these lines should certainly be enacted. Time was when we could afford to neglect our superabundant forest growth; but with our present growth in population the demand has already outstripped the visible supply, and the end is already in sight, unless we take every precaution not only to prevent waste but to encourage the renewal of forest growth. The rational management of our forest areas, especially on the Pacific Coast, will entail a large staff, systematic methods and the expenditure of a large amount of the public funds, and much of the present apathy of Congressmen is based upon the evident cost of proper regulation of forests. But without decided steps taken in the direction pointed out, bad conditions will rapidly grow worse, and it needs no elaborate calculation to prove that, in the near future, the total destruction of our forests will entail a public loss out of all proportion to the cost of preservation, large as the latter may be.

Present conditions and the urgent demands for relief arise from our past absurdly wasteful system of disposing of the public domain. Up to a date which is hardly a generation ago half a continent lay unclaimed and unsettled; and with the purpose of attracting population to this vast area land was given away to any one who would promise to live upon it, and this land was donated without any restrictions as to use or abuse. Great areas, once covered by valuable timber, have been burned over, by accident or design, or from natural causes, and just that much wealth has been permanently lost to the country. In other great sections lumbering industries have been carried on upon such wasteful and destructive methods, that the good timber is now exhausted and the land remaining is valueless for other purposes. In regions of scanty rainfall the destruction of the forest cover on the higher elevations and mountain slopes is promoting floods and the too rapid run-off of water that this timbered land would have otherwise stored for useful flow. In other words, the time is at hand in our national life when we should check this waste of public wealth by the exercise of governmental authority and supervision over a fast-disappearing asset of the common fund. Statistics prove that we cannot afford further to allow our timber supply to be wantonly destroyed: and while, thanks to the unwise liberality of the government in the past, we cannot control the use of land already disposed of, we can and should care for all the timber that still remains upon the so-called public domain. Provided that the system of supervision is a systematic and thorough one, honestly and efficiently administered, the policy proposed is an economical one, whatever the actual outlay may be.

LETTERS TO THE EDITOR.

A Good Field for Graduates in Civil Engineering.

Sir: For several years past I have received hardly a mail that did not contain one or more applications for employment from young engineers, in addition to numerous personal applications, particularly from young men just graduated from our engineering schools. The excess in the number of these applications over the demand in this class of service, and the difficulty I have experienced in securing educated and intelligent engineers, with a practical knowledge of track work, for positions in the roadway department, has constrained me to write a letter, of which the attached is a copy, to a young man who applied for employment in my department. It may be of some benefit to other young men similarly situated, and I therefore send it to you for publication if you see fit.

Yours truly,
J. F. Wallace, M. Am. Soc. C. E.,
Chief Engineer, Illinois Central R. R.

Chicago, Ill., April 30, 1897.

(The following is the letter referred to by Mr. Wallace, omitting names.—Ed.)

Sir: Your letter of April 27 has been forwarded to me out on the line. As you are probably aware, there is at the present time a supply of young men desiring to enter the profession of civil engineering, which is greatly in excess of the demand. I presume not over 20% of the graduates of our engineering schools secure purely engineering positions, and a large percentage of this class in one or two years become discouraged from lack of work and the incidental hardships of the profession, and drop out of the ranks.

The Engineering Department of the Illinois Central R. R. has also charge of the maintenance of way and structures. In this maintenance department I have 14 roadmasters, whose rate of compensation per year is from $2,000 for the first class to $1,800 for the second class and $1,500 for the third class. They each have charge of from 200 to 400 miles of track. Under the Roadmasters are the Supervisors, who have charge of about 100 miles of track each, and receive from $100 to $125 per month. The Section Foremen under the Supervisors have six or seven miles of track to look after. Out of the 14 Roadmasters there are 8 who had received an engineering education and had had considerable practice as civil engineers before they accepted their present positions. Some of the Supervisors are also engineers. It is my desire to fill these places, as far as possible, with competent, educated engineers, provided I can secure men who, in addition to their technical training, have a practical knowledge of the details of track work and experience in handling men, and have acquired their experience on the Illinois Central R. R. The opportunities for the average civil engineer to acquire this intimate knowledge of track work are limited, and as a consequence men of this class with these qualifications are scarce.

I would suggest to you and your friend the advisability of entering our track department. As apprentices in this line working on a section, you would receive from $1 to $1.25 per day, depending upon the part of the line where you might be employed. If you are bright, intelligent and industrious, and not afraid of hard manual labor, in the course of a year you should have acquired that knowledge of track and the details of roadway maintenance which would render you competent to handle a section as Foreman. The pay of Section Foremen ranges from $45 to $50 per month, according to location and importance of work. After one or two years' experience as Section Foreman you would probably be qualified for promotion to the grade of Supervisor, and from that to Roadmaster. Roadmasters, in common with others, are in line for promotion to the higher ranks of railroad service. This is the only branch of engineering work that I know of which is not crowded with experienced and competent men, and is a field of work which I would recommend to young men who have received an engineering education and who desire a definite line of special action which will give constant employment, with chances of speedy promotion for competent men.

Yours truly,
J. F. Wallace, Chief Engineer,
On Mississippi Division, April 30, 1897.

Chute at Willow Grove Park, Philadelphia, Pa.

Sir: Having noticed in your issue of March 11 the description and cut of a chute in use at Willow Grove Park, near Philadelphia, it strikes me that this is an infringement on the chute built by me in 1894, under patents owned by the Paul Boynton Co. I send herewith a cut

CHUTE ERECTED BY THE PAUL BOYNTON CO. AT CHICAGO, ILL., IN 1894.
W. L. Stebbings, Chicago, Ill., Designer.

showing the Chicago chute in operation. The photograph from which this cut was made was taken in July or August, 1894, and since then over twenty chutes have been built in various parts of the world under these patents.

Yours very truly, W. L. Stebbings.

Chicago, Ill., March 25, 1897.

The Efficiency of the Air-Lift Pump.

Sir: The letter of Mr. E. E. Johnson on the subject of the Air Lift Pump, published in your issue of April 22, has decided me to also offer some opinions on this subject.

Since you brought the air lift pump to the attention of the profession by an article in Engineering News of June 8, 1893, you have published a number of reports on the operation of this pump from which valuable information may be gotten, but not as much as could have been gotten from the labor, time and money expended had the operators understood how many factors there are affecting its action and had they systematized their trials accordingly, and recorded all the data necessary to a proper study of results.

You have also published several letters setting forth the theory of their respective writers as to the action of the pump. The ideas thus presented are various, and in my opinion all show that the complexity of the action is not appreciated.

It would be unfortunate should Mr. Johnson's theory and computations be accepted unchallenged, even so far as they can be understood. His use of the term "specific gravity" is confusing and his insertion of the word "obviously" is not, it seems, always justifiable. Some of the air compressor makers may object to the efficiency of compression assumed by Mr. Johnson, but this is irrelevant until we can better formulate the efficiency of the pump independently of that of the compressor.

For the benefit of those studying the theory of this pump and for those experimenting for information I give below a list of the conditions, a change in any one of which will modify the action of the pump.

Letters are for reference only and do not indicate the order of importance nor of effect.

(a) Depth of submersion of point of air discharge below still water surface.

(b) Velocity of water at point of air discharge.

(a) and (b) determine the necessary air pressure. If (a) is constant, the pressure decreases when (b) increases.

(c) Area of main, or water discharge, pipe.

(d) Net lift to point of water discharge—including velocity head at that point.

(e) Volume of air (at atmospheric pressure) discharged per unit of time.

(f) Ratio of expansion of air as it rises through the main pipe; (f) may be considerably modified by the temperature of the water.

(g) Total volume of air in main pipe at any instant. This determines the specific gravity of the discharging column.

(h) The volume of each individual bubble within the main pipe and therefore the form and area of the air inlet.

It seems that Mr. Johnson has failed to consider factors (b), (c), (f), (g), and (h).

The factor (h) is the one most difficult to determine or to control, nevertheless it is the one most affecting the efficiency.

In asserting the above it will be seen that I do not accept as correct the claims made in the Pohle patent—that the air forms water-tight pistons in the water pipe. This condition can only be realized in toy pumps, in which capillary action, or surface tension on the bubble, have a controlling influence. In large pipes the bubble ascends relative to the surrounding water even while both are moving upward. It is in this "slip" of the bubble that the chief loss of energy is to be found.

The writer believes it to be impossible to embody all the above-named factors in a mathematically correct formula for efficiency, but certainly they must all receive consideration before satisfactory empirical rules can be formulated from results of experiments.

Elmo G. Harris.

School of Mines, Rolla, Mo., April 26, 1897.

(In the "Journal of the Franklin Institute" of July, 1895, Prof. Harris published an article on the Theory of the Air Lift Pump, to which we would refer any of our readers who desire to investigate the subject from the mathematical side.—Ed.)

Disagreeable Effect on Railway Curves.

Sir: In the communication of Prof. Raymond, in your issue of April 15, headed "Concerning Disagreable Effect on Railway Curves," there seems to be quite as much room for misunderstanding as in Mr. Wellington's discussion of the same subject in his "Economic Theory of Railway Location."

Does the former mean that the greatest comfort in riding, is when the cars have their greatest tip towards the center, as would be the case with very slow speeds upon a canted track, and that the comfort diminishes with the increase of speed until it reaches a minimum, or its "limit," when there is no tip from the line of pressure of the cars upon the track? This inference could readily be drawn from his letter. If the tipping is the element of comfort or discomfort, why should the outward tipping produce discomfort and not the inward?

Mr. Wellington apparently assumes that the tipping either way is uncomfortable, and that when the outward tipping passes the point where the floor of the car would be level, with the track canted ½ inch to the degree, the discomfort becomes "objectionable," or in other words, the comfort has reached its limit. It is necessary to assume a certain range for comfort before it becomes discomfort, otherwise its limits would be zero.

The speeds given by Prof. Raymond, which he calls the "Limit of Speed for Comfortable Riding," in reality are the speeds of greatest comfort for the given cant of track. Therefore, if comfort has any range or limits, those limits would extend to both higher and lower speeds.

Yours, &c., A. Onderdonk.

Hagerstown, Md., April 19, 1897.

Sir: Mr. Onderdonk's criticism of my use of language is entirely just. I am very ready to accept the term "Speed of greatest comfort." I had in mind that the tendency would be to run as fast as possible or permissible, and hence the term "limit" suggested itself and was hastily used. The discussion in "Economic Theory" is, however, incorrect, as pointed out by Mr. Taylor, even on the assumption that car floor level gives greatest allowable discomfort.

Very truly,

Wm. G. Raymond.

Troy, N. Y., April 29, 1897.

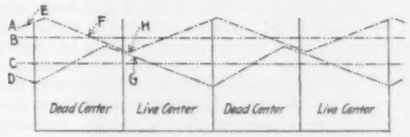
The Device of the American Energizer Mfg. Co., Ltd.

Sir: Referring to the statement on p. 201 of your issue of April 1, 1897, stating "Another inventor who proposes to multiply power is Benjamin C. Pole, at Room 53 Atlantic Building, Washington, D. C., and whose works according to a circular before us are at Deanwood, D. C." The above statement is incorrect so far that Benjamin C. Pole does not propose to multiply power, next it is only necessary for engineering news to look at G. M. Hopkins map 1901 of the District of Columbia to see the works mentioned.

It is very evident that the personal interviewer neglected to even ask to see the machinery or to have it explained or if he had liked to test it for himself. As it has all been built in an open shop and anybody asking to see the machinery was always well treated. The circular gives no direct explanation towards describing the invention, starting with Letters patent of the U. S. No. 382,008, May 1, 1888. The plan is as follows: keyed upon the main shaft is a flywheel six times as heavy as is ordinarily used for flywheels (used on that size of engine) and loosely mounted on the same shaft is placed the working driving pulley. The rim of this pulley is calculated to be twice as heavy as is ordinarily used in engine flywheels for the size of cylinder used. Between the above mentioned heavy flywheel and the loosely mounted driving (heavy) pulley is a friction clutch and mechanism which automatically attaches and detaches these wheels one from the other.

The friction clutch is made to disconnect the flywheel from the pulley wheel when the crank axle is about 45° from the horizontal and the detached heavy flywheel is accelerated energized for 90° at the completion of this 90° it is reattached by the automatic friction (brake) clutch and the gradual application of this clutch in reattaching pulls the working driving pulley upto the speed of the heavy driving flywheel—under the laws of impact and collision.

By this plan the indicator cards only show the necessary steam to energize the heavy flywheel (released from working load) to give that wheel the required speed; now simply because the heavy flywheel is made subsequently to collide by a slipping friction and carry along the driving pulley with the load. Speed that latter wheel. All this does not alter the indicator card, that card only showing the necessary steam to accelerate and run at a speed the heavy flywheel. Any alteration in that indicator card would only be detectable in acceleration of the piston during stroke.



New Diagram.

As to the weights of the metal used in the heavy flywheel:

So as to make a 10 HP. engine.

Take, for instance, 30 lbs. per horse power, 30 lbs. × 6 = 180 lbs., and for 10 HP. = 1,800 (this weight can be changed by arranging for larger diameter of wheels, with less weight of iron on the rim of the flywheel in consequence of higher velocity of rim). Now the loose working driving pulley (24 ins. diameter) should be 30 lbs. × 2 = 60 lbs., and for 10 HP. 600 lbs. (The cylinder here understood and tested is 5 × 5 ins. with the loosely mounted driving pulley 24 ins. diameter the flywheel is 3 ft. diameter and weighs 1,800 lbs. to make 250 revolutions per minute.)

Now therefore if 30 lbs. of metal at 250 revolutions per minute at 12 ins. radius is good for one horse power for the dead center arc of 90° twice in a revolution, then 60 lbs. stands for two HP. under like conditions and 600 lbs. stands for 10 HP. under the same conditions of speed. This is correct for any single cylinder engine.

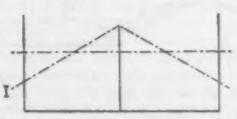
This ratio is good for the loosely mounted driving pulley and the duty of accelerating this 600 lbs. pulley with the working load on it is accomplished by the 1,800 lbs. pulling at slightly a higher speed—by pulling the 600 lbs. pulley up to it—equalizing speeds.

In and by the act of accelerating the loose driving pulley with the working load, the heavy flywheel looses speed and both wheels assume nearly a common velocity under the laws of impact and collision. Two bodies moving in the same direction of motion with unequal velocities and of unequal weight. What is the velocity common to both after impact?

The following diagrams of the speeds of the two wheels are interesting and one is entirely new in engineering, the second diagram is old. The diagram is supposed to cover a revolution of the engine, at governor speed.

A represents the highest and lowest speeds of the 1,800-lb. flywheel.
B, the mean speed of A.
C, the mean speed of D with working load of 10 HP.
D represents the highest and lowest speed of the 600-lb. flywheel.
At E the friction clutch commences to close and pull line D.
At F the speeds are about equalized.
At G wheel D left to itself with the work has the regular diminuation of speed.
At H the heavy flywheel is accelerated without the working load.

It will be seen that the line I corresponds to that of D very nearly—and that the line I with the working load



Old Diagram.

is energized by the 1,800-lb. flywheel which is economically maintained at speed—

Test 1.—Try 1,800-lb. flywheel, cylinders 5 × 5 ins. and 80 lbs. steam, said wheel keyed to crank shaft—attempt to use 250 revolution with friction brake set for 10 HP. on a Fairbanks scale AND THE BRAKE WILL STOP IT.

Test 2.—Try 600-lb. flywheel keyed on shaft with same size of cylinder and pressure of steam set a friction brake for 10 HP. on a Fairbanks scale AND THE BRAKE WILL STOP IT.

Test 3.—Try both wheels together and the brake will stop them.

Test 4.—Try the engine with regular weight of flywheel and the brake will stop it.

Test 5.—Put in the pulsation energizer, and the engine runs 250 revolutions with 10 HP. friction brake on Fairbanks scale.

It will be seen that there is a regular change about in the acceleration of the loose driving pulley. And all the steam has to do is to keep 1,800 lbs. of iron moving at a governed speed, the iron will do the rest of the work. The lower line reperesents 10 HP.—with cylinders only 5 × 5 ins., steam pressure 80 lbs., revolutions 250. This is the new way of the Energizer Momentum Engine, and without the invention, the old way 5 × 5 ins., 250 revolutions, 80 lbs. steam, you can figure for yourselves. The engines came from H. M. Siple, of 3d and Arch Sts., Philadelphia, Pa.

Yours, Benjamin C. Pole,
Inventor and President,
American Energizer Mfg. Co., Limited.

Room 28, Atlantic Building, Washington D. C., April 23, 1897.

(According to the above letter (which we print exactly as received), Mr. Pole does not propose to multiply power; he only claims to take more power off his 1,800 lbs. pulley than he could take from the flywheel which is driven directly by the engine. In his own words, "all the steam has to do is to keep 1,800 lbs. of iron moving, and the iron will do the rest of the work." Further comment by us would be superfluous.

In this connection, however, we notice with interest in the New York "Herald" of April 25 a column article headed as follows:

HIS MOTION PERPETUAL.

Benjamin C. Pole Claims to Have Solved the Great Problem.

If Successful the Question of Coal Need Not Trouble Us Any More.

The device referred to is not the "energizer" which is described above, but a differential gear apparatus, which we will not take space to describe, further than to quote from the "Herald" as follows:

Whether he (Mr. Pole) has discovered a means of creating an unlimited amount of power from very small beginnings, or, technically expressed, will make his mechanism develop a vastly greater amount of power in foot pounds than that required to drive it, remains for the present a very interesting problem. * * * If the decision should be a favorable one, it would mean practically that a 5-HP. engine could be made to develop a hundred horse power, or, for that matter, any amount of energy.

In a letter replying to our inquiry as to the correctness of this description, Mr. Pole says:

The motion in question is perpetual when followed by a good engine motion. * * It is a mechanical device which will permit an increase of length of lever without corresponding increase of motion to the driving power.

Our readers will doubtless be able to satisfy themselves from the above whether Mr. Pole claims to multiply power or not.—Ed.)

A Riverman's Plan for Preventing Floods on the Mississippi.

Sir: There seems to be a great deal of talk just now about levees and high water and the remedy to be applied for preventing floods. The U. S. Engineering Department seems to be at sea without a rudder to steer by; but to a practical riverman the thing is as plain as the noonday sun.

The right way to stop disastrous floods is to rip-rap the shores, and keep them from cutting and forming bars in the channel, and let what sediment comes down the river deposit itself on the land with the overflowing water. In a very few years the channel will grow deeper and the land will grow higher; and in one generation the river will be so deep and the banks so high that an overflow would be rare.

On the other hand, the U. S. Engineers are at work making the land lower and the river bed higher year by year, by permitting the river to constantly cut away the banks. And as the sediment carried down the river by floods is fenced in by the levees it must also be deposited in the river. As a proof of the value of rip-rapping the banks, we have the case of the Missouri and other rivers which are dirty with sediment until frozen over; but as soon as these rivers are frozen and the wash of the banks prevented the water becomes very clear. Now, I contend that if the banks of these rivers were protected by rip-rap the waters would be clear the year around—as clear as when the surface is frozen over.

The money spent by the U. S. Engineers in surways, dredging outfits, wing-dams and levees proper, would go far towards providing the rip-rap, which I believe would settle the question for all time. Ten millions have been

expended already to apparently little purpose in stopping floods. Let them now try rip-rap. Yours truly,

Elsberry, Mo., April 26, 1897. J. Richtman.

Suggestion as to Relieving the Mississippi Levees.

Sir: I have seen a number of suggestions relating to the shape of dykes and the material to be used in building levees along the Mississippi River. But it seems to me that most people will conclude, after reading late accounts of the destruction of property and even of human life along the lower river, that the material and cross-section are secondary considerations. If the flood water rises above the levees it matters little whether these are built of stone or of mud; and if the levees are so located that the current impinges directly upon them, they would be undermined in either case, and whether vertical or sloped at 3 to 1.

I believe that the true solution of the problem of preventing inundation lies in providing flood-water channels,

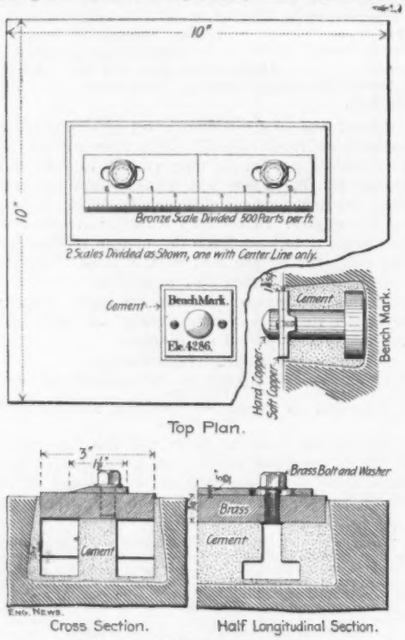


Fig. 4.—Scales on Monuments.
(One-fourth size.)

or cut-offs. The river attempts to do this work for itself in time of high water, and by assisting nature we may prevent the accumulation of an amount of potential energy which is disastrous under present conditions. Wherever the flood water can be turned directly into the Gulf, as through the channel of the Red River, in Louisiana, it seems to me it should be done, as a relief to New Orleans and the country between that city and the Red River. In other cases, wherever the channel makes a sharp turn, a flood-water channel should be made through the intervening neck and leveed with the bottom of this cut-off 10 ft. below the danger-line. There is no reason why a levee system should raise the bottom of the river by silt deposits, except where bends in the river act as an obstruction. In a straight channel, the confining of the river to its banks should certainly tend to deepen the channel and increase the current. Yours respectfully,

W. F. Waters, C. E.

Baltimore, Md., April 26, 1897.

(As late events prove, the problem of controlling the floods of the Mississippi is an exceedingly complex one; and in its flood height at various points and in its course the river is a law unto itself that seems to brook little interference. We fear that with the much straightened channel, suggested by our correspondent, the resulting flood-velocity would seriously effect the engineering works along the line of his cut-offs and bring about conditions quite as bad as those existing. The deepening of the Atchafalaya, a mouth of the Red River, and the resulting trouble, is a case in point.—Ed.)

NOTES ON MUNICIPAL ENGINEERING WORK AT SALT LAKE CITY.

(With full-page engraving.)

In the "Notes of a Transcontinental Trip," in our issue of Oct. 15, 1896, reference was made to the systematic way in which the city engineering department is conducted, and some particulars were given of the work of this department. In the present issue we give some further details, compiled from drawings and information furnished by Mr. Frank C. Kelsey, City Engineer.

The city is laid out on the rectangular plan, as was shown by the map in our issue of Jan. 4, 1894, but the plan is not uniform throughout. In the older part of the city the blocks are about 660 × 660 ft., with streets 132 ft. wide, while in the northeast section (beyond South Temple St. and State St.) the blocks are about 330 × 330 ft., with streets 82½ ft. wide. Under the systematic administration of the engineering department introduced by Mr. A. F. Doremus, M. Am. Soc. C. E., when he became City Engineer in 1890, the entire city was resurveyed with great care, and monuments were placed at all street intersections. There are four main base lines, two running north and south, and two running east and west.

Block plans of the city, on blue-print sheets, about 25 × 25 ins., are used to show various details of the engineering features, and one of these is a diagram showing the distances between the street monuments, only the center lines of the streets being shown, with circles to mark the location of the monuments. The blocks are numbered and all distances between monuments are shown, together with the station marks of each monument. In most cases the monuments are set 2 ft. north and 2 ft. west of the center of street intersections. The street monuments, Fig. 1, are hard sandstone blocks 8 ins. square on top, with two intersecting grooves on the top to mark the station point. These blocks are about 30 ins. high, and are set with the top 6 ins. below the grade line of street surface. The top is enclosed in a brick chamber, 12 × 12 ins., built of hard burned brick laid in cement mortar, composed of 1 part Portland cement to 2 parts sand, and a layer of concrete is rammed between the wall and the monument, holding the latter firmly. This concrete is composed of 1 part Portland cement, 2 parts sand and 3 parts fine gravel. The top of the chamber is fitted with a cast-iron manhole frame and cover.

The distances given in the diagram of street monuments, already referred to, are horizontal distances calculated from measurements taken along the ground line with a 400-ft. steel tape, which is in adjustment with the city standard of length at a temperature of 65° F. and a tension of 30 lbs. In 1890, when the re-survey was begun, a standard of length was established in Liberty Park. This standard consisted of stone monuments set firmly in the ground, having brass plates in the top marked with a cross, fixing the length. In order to have the standard located where it would be convenient and also for the purpose of making some changes in its construction, a new standard, constructed in accordance with the plan was installed last year in the grounds of the City and County Building (illustrated in our issue of Oct. 15, 1896. There are three monuments, the first and second being 100 ft. apart and the first and third 400 ft. apart. These monuments, as shown in Fig. 2, are granite posts 6 ft. high, 16 ins. square at the base and decreased to 10 × 10 ins. at the top. Each post is set in a heavy bed of concrete with a base 4½ ft. square, the concrete being composed of 1 part cement, 2½ parts sand and 4½ parts gravel. The top is enclosed by a brick chamber and a cast-iron box, with sand filling between the monument and the box, while the upper part of the box is of bronze and has a bronze cover secured by a staple and padlock. The details of the box are shown in Fig. 3. The details of the mountings on the top of the monuments are shown in Fig. 4. The second and third monuments have graduated scales (divided with 500 parts per ft.) as shown in the cut, but the first one has a scale with center line only. In the first monument a bench mark, consisting of a hard copper plug enclosed in cement in a dove-tailed pocket in the stone, is fixed. This bench mark is the official or standard bench mark from which the elevations of all other bench marks in the city are determined.

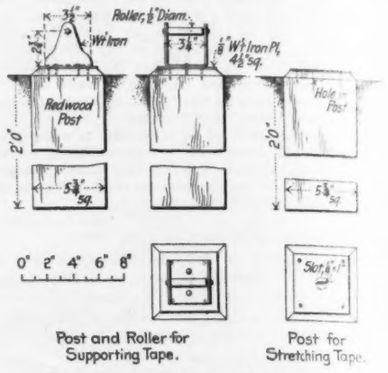


Fig. 5.—Intermediate Support for Steel Tape.

The tape is supported at intervals of 25 ft. by ½-in. rollers in iron frames set on top of redwood posts 5¾ ins. square, 24 ins. long, as shown in Fig. 5. A similar post, also shown in Fig. 5, is placed to receive the tape-stretching device, Fig. 6. In this device the loop of the tape is attached to the hook in the screw, while the ring secured by chains to the oak frame is attached to a short brass chain with a flat hook, which is hooked into the plate on the top of the post. The man at the zero end draws the tape tight with the screw until the zero mark is exactly opposite the center line of the scale. The man at the other end uses a spring balance attached to the hook of the stretcher and the end of the tape; he tightens the tape with the screw until the proper tension is secured and the difference between the length of the tape and the standard is then read from the graduated scale. The edge of the scale on the monument is the same thickness as the steel tapes used so that the graduations on the tape and the scale are on the same plane and the difference between the length of the tape and the standard is easily read to thousandths of a foot. Fig. 7 shows the operation of testing the tape. On the right is the tape stretching device, and on the left is the open monument box, exposing the graduated scale on top of the monument. The temperature is taken when the tape is compared and the correction to be applied is read from the tabulated statement.

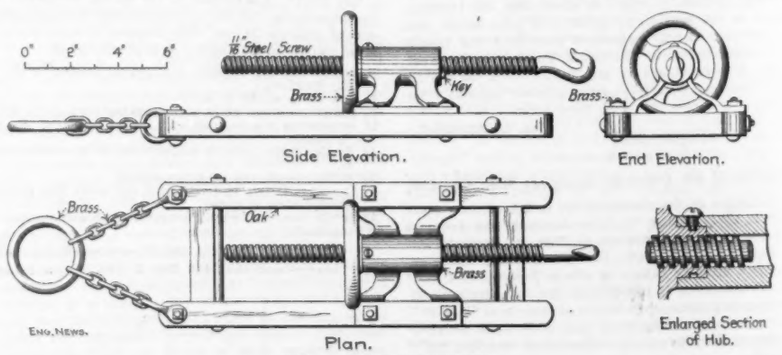


FIG. 6.—TAPE STRETCHER.

Another of the blue-print plans, already referred to, shows the established street and sidewalk grades. This shows the streets, the numbers of the blocks, the elevation of grade at each corner of each block. Figures with arrowheads on the street

opposite each block show the rate and direction of the grade.

The form of the stone monuments used in marking the west boundary line of the Salt Lake City corporation is shown in Fig. 8. These are posts of hard sandstone free from laminations, and are 5 ft. 9½ ins. long, with 2 ft. 6 ins. set in the ground. The upper part has rock faces, with ½-in. chisel drafts on the edge, and on one side is a shelf with a station point indicated by a copper nail in a lead-filled pocket in the stone. On the face above this shelf is a cast brass plate, lettered "S. L. C. C. Limits," let into the rock and secured by Portland cement filling, as shown.

On the very wide streets in the business portion of the city a combination of asphalt and stone block pavement is used, and this arrangement is shown in Fig. 9, which represents a cross-section and part plan of Second South St. On these streets streams of water flow along the gutters, and it is necessary to carry this water in covered conduits at the street crossings. The conduits are of concrete, lined with cement plaster, and covered with 1-in. cast iron plates, having a checkered top surface, the roughened part of which is ⅛-in. deep. Details of these conduits, of the gutters and of the curbing are given in Fig. 10.

The records of street construction work are kept in books, with pages 7¾ × 10¼ ins., each block of street being taken separately. On one page is a drawing by hand showing the width of that sidewalk, etc., and the length of frontage of each property owner. An example of this is shown in Fig. 11, reproduced from a photograph of one of the drawings, and the style of keeping the records of work and cost are shown in the accompanying tables.

SAMPLE PAGE FROM RECORD OF STREET PAVING IN OFFICE OF CITY ENGINEER, SALT LAKE CITY.

Statement Showing Extent and Cost of Abutters' Portion of Stone Block and Asphalt Pavement on West Temple St., from South Temple to Fourth South St., in Paving District No. 3. (Work done by Contractor.)

Items of cost.	Rate of cost, per sq. yd.	No. sq. yds. in district.	Amounts.	
Stone blk pvmt.*	$2.9756893	5,877.20	$17,488.72	
Haul	.13612100	"	800.01	
Engineering	.03261073	"	191.66	
Inspection	.02779336	"	163.35	
Extra work	.00072994	"	4.29	
Advertising[1]	.00098193	"	5.77	
Advertising[2]	.00433928	"	25.50	
Totals	$3.17826554	5,877.20		$18,679.30
Asphalt pavemt.	$2.97000000	14709.25	$43,686.47	
Haul	.13612100	"	2,002.23	
Engineering	.03261073	"	479.69	
Inspection	.02779336	"	408.81	
Advertising[1]	.00098193	"	14.41	
Advertising[2]	.00433928	"	63.84	
Totals	$3.17184630	14709.25		$46,655.48
Flagstn. (crswlk)	$0.73000000	157.50	$114.97	
Haul	.015124556	"	2.38	
Engineering	.01002500	"	1.58	
Inspection	.00854420	"	1.35	
Advertising[1]	.00030183	"	.05	
Advertising[2]	.00133359	"	.21	
Totals	$0.765329176	157.50		$120.54
Total for district				$65,455.52

$65,455.32 Total cost.
5,149.4 Front feet of abutting property.
$13.90 Engrs. estimate, front ft. of abutting property.
12.71 Cost per front ft. of abutting property.

$1.19 Excess of engineer's estimate over actual cost.

* Contract price, $3.15; deduction made for shortage in amount of paving pitch used.
[1] By Board of Public Works.
[2] By Recorder.

West Temple St. Pavement, District No. 3. (Work done by Contractor.)

Nature of work.	Quantities.	Amounts.
Abutters' portion:		
Stone curbing	1,191.19 lin. ft.	$1,329.58
Stone block pavement	1,499.41 sq. yds.	4,765.52
Asphalt pavement	3,779.45 " "	11,987.83
Total		$18,082.93
Street Railway Co.'s portion:		
Stone block pavement[1]	1,325.70 sq. yds.	$3,212.73
Stone block pavement[2]	202.62 " "	811.23
Total		$4,023.96

[1] Work done by Street Supervisor.
[2] Work done by Contractor.

A 48-IN. WATER MAIN WAS TAPPED FOR A 36-IN. connection without shutting off the water supply from the main at the Ridgewood reservoir, Brooklyn, on April 29. The work was done by the Smith tapping machine, made by the A. P. Smith Manufacturing Co., of Newark, N. J.

A REPORT ON STANDARD TESTS FOR PAVING BRICK.*

The tests which were originally designated for investigation, with a view to making use of them as a means of estimating the quality of brick for paving purposes, were: 1, Rattling, as a measure of toughness and wearing power; 2, Absorption, as a measure of vitrification and resistance to freezing; 3, Cross breaking, as a measure of structural perfection and freedom from defects due to manufacture; 4, Crushing, as a further indication of the same factors; 5, Hardness, as a confirmatory test of vitrification; 6, Specific gravity, as a guide to the density and fineness of texture of the material.

Rattler Test.

The rattler test, in order to give comparable results, and to be sufficiently vigorous to give data of value and yet not so vigorous as to ruin any materials which might be put into it, before giving an opportunity to judge of their relative wear, required a very careful and systematic investigation.

Before beginning on this active work of testing, it was above all things necessary to obtain a standard sample of paving bricks, whose uniformity should be developed to the highest point attainable under actual manufacturing conditions.

The Canton Brick Co., Canton, O., made offer of a carload of brick, to be selected from a kiln of their wares on any terms I might dictate. The number required was chosen in a compact block from the heart of a kiln of pavers. Stripping off the two top covers a block 10 courses deep and 14 courses long was removed, keeping five courses from the bag walls on either side and seven courses from the wicket. There were 16 courses underneath those chosen. All liability to air checking, soft burning, overburning, etc., would thus be reduced to a minimum. These bricks were carefully drawn and shipped to Columbus and stored as a permanent supply in the testing rooms of the clay-working laboratory of the Ohio State University.

The rattler employed in most of the succeeding work was one built to order for the university, according to the provisional specifications adopted at the first meeting of the commission. It was 28 ins. diameter and 61 ins. long, with a movable diaphragm, capable of adjustment backward and forward, making two chambers of variable length. It was a regular polygon of 14 sides, in cross section, and was strongly built of soft gray cast iron. It was driven by gear and pinion, with a ratio of 8½ to 1 and by a 16-in. pulley, 6-in. face. A constant speed electric motor of 15 HP. furnished the power.

The first point to be ascertained was the quantity of material which would occasion the greatest loss by rattling. Inasmuch as all bricks and stones vary considerably in specific gravity, it is plain that volume would be the only fair basis of comparison. Hence a series of charges were weighed out, whose aggregate bulk amounted, respectively, to 5, 10, 12½, 15, 17½, 20, 22½, 25, 30, 35 and 40 % of the internal cubic contents of the rattler. These were rattled for 1,000 and 2,000 revolutions each, and then losses tabulated.

The results show that a maximum loss occurs when 15% up to 22½% charges are used; 10% and 25% are slightly below this maximum, while 5% and 30% and above fall off rapidly in losses, due on the one hand to too little crowding and on the other hand to overcrowding and lack of room to fall. The practical lesson from this investigation is that not less than 10% should be used for any test and that no gain can be had by employing charges of more than 15% in volume. The next point to demand attention was the effect of time on the rate of loss by rattling. How long shall a test be rattled? Does it make any difference on the rate of wear? To settle this point four charges of 10, 12½, 15 and 20% volume, respectively, were rattled for periods of 10 minutes, or 250 revolutions, each, and weighed; and then for other periods of 10 minutes each until each charge had received in the aggregate 80 minutes' rattling and 8 weighings. The losses, being tabulated, showed that the rate of wear was greatest in the first 10 minutes, and less in regular order for each subsequent period.

FIG. 7.—TESTING STEEL TAPE FOR STANDARD LENGTH.

But after 40 minutes, or 1,000 revolutions, the rate of wear was only slightly less each time, and was plainly due to real wear, while the earlier losses were just as plainly due to corners and edges being knocked off. The evidence shows that not less than 1,000 revolutions would give correct comparison, and also that a longer test of 1,500 or 2,000 revolutions would be better, as it would give the brittle bricks a chance to average up with softer burnt, tough bricks, which lost only by wear and not by chipping. That the former suffer worst at first is certain, and that they suffer least at last is probable.

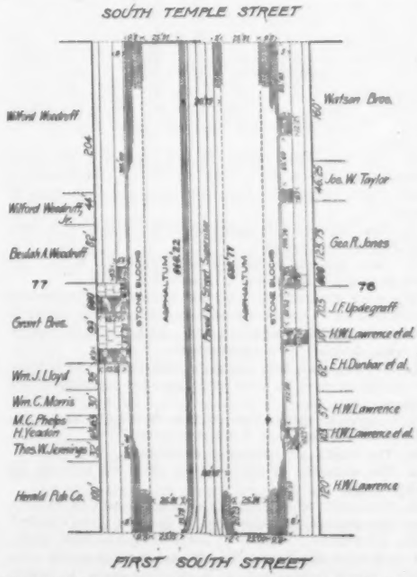


Fig. 11.—Sample Page of Street Record Book; Salt Lake City.

*Report of the Committee on Paving Brick Tests of the National Brick Manufacturers' Association, presented at the annual meeting held in Buffalo, N. Y., in February, by Prof. Edward Orton, Jr., Secretary of the committee. The specifications for rattler tests and absorption tests were adopted by the association. Our abstract is made from the report as published in the "Clay Worker," the editor of which, Mr. T. A. Randall, is Secretary of the association.

The next point to be proved was the effect of the length of the chamber used in rattling. If all rattlers used for brick testing were made for this purpose and of uniform size this test would be unnecessary. But, as a fact, the rattlers used in the past include every size, every length, every speed and every kind and quantity of charge. Hence, to get uniformity of results all conditions which can affect the rate of wear must be made the subject of accurate specifications. To test the effect of length, charges of 10, 15 and 20% were weighed out, and rattled in chambers whose diameter was always 28 ins., but whose length by means of the adjustable diaphragm was made 12, 18, 24, 30, 36, 42 and 48 ins., respectively.

The tabulated results show that the rate of losses is practically the same for each volume of charge employed, and the fluctuations indicate no fixed tendency, either up or down. From this it is fair to conclude that the length of the chamber is of no importance, if a standard volume of charge be employed in each case.

The next variable element to be considered was the diameter of the rattlers. Engineers have used in the past rattlers from 16 ins. up to 36 or 48 ins. diameter. It is hardly conceivable that results are the same in all of these sizes. Accordingly, the use of a series of rattlers of 16, 18, 20, 22, 24, 28 and 34 ins. diameter was secured in various shops and foundries, and charges of equal per cent. of volume were used in each at a uniform speed for a uniform time. The results, when tabulated, show that the rate of loss increases, all other things being equal, with the diameter up to 28 ins. Increase above that size showed no increased rate of loss.

It is to be further considered that the uses to which rattlers are ordinarily put divide them naturally into two classes: the small ones for light work, which vary from 12 to 20 or 22 ins. diameter, and large rattlers for heavy work, which vary from 26 to 48 ins. The intermediate size of 24 ins. is a very rare one in the city of Columbus, at least, and none could be found after a search extending over one hundred different machines. The tests made on that diameter were finally obtained from the St. Louis Testing Laboratory, from bricks shipped there for that purpose. Consequently, in order to make these tests widely useful, a size must be selected which engineers can obtain easily, and this would necessitate the use of machines of large diameter (from 26 ins. up), rather than the smaller sizes, which are, of course, much less vigorous in their effects.

Also, since larger sizes than 28 ins. seem to fail to produce proportionately greater wear, and since larger sizes would, of course, demand the use of larger and larger quantities of bricks to fill them to a standard volume, it follows that no benefit can be obtained by using sizes above 28 or 30 ins.

The remaining condition affecting the use of the machine itself is that of varying speeds. The question to be determined is whether the duration of a test can be measured in time or in revolutions where speeds are different or variable. In other words, is the loss per revolution the same for all speeds, or does it vary with each speed employed? To determine this point, charges of one volume were rattled successively in the same machine under exactly uniform conditions, excepting that of speed, which was varied from 16 to 48 per minute, by changing the driving pulley of the rattler from smaller to larger sizes. The charges were weighed after running 1,000 revolutions and 2,000 revolutions, and also after forty minutes' running time, regardless of rate of revolution. The data, on being worked out, show clearly the following results:

1. The losses per revolution are practically the same between 16 and 48 revolutions per minute, there being a very slight increase between low rates and high rates of speed.

2. That the losses on equal terms increase directly with the rate of revolution.

3. That between 24 and 36 revolutions per minute the rate of loss per revolution is practically uniform.

The work done to this point has shown very clearly the conditions as to machinery and operation which ought to prevail in making a standard test. To bring them clearly in order they are here summarized:

1. Not less than 10% nor more than 15% of the volume of the rattler need be filled with the cubic contents of the charge.

2. It must be rattled for not less than 1,000 and preferably for not less than 2,000 revolutions.

3. The length of chamber is immaterial.

4. The diameter of the chamber must be between 26 and 30 ins.

5. The speed of revolution, between 24 and 36 revolutions per minute, is immaterial if the test is terminated when the requisite number of revolutions has been made.

Armed with this knowledge, the commission could have made a report recommending the standard tests. In order, however, to try in every possible way to conserve the interests of the brickmakers, and to avoid recommending any tests which would require them to furnish unnecessarily large quantities of material for tests, the experimental work of the rattler test was greatly extended.

It is plain that if the volume of a charge must be maintained at a fixed quantity, and that rattlers of somewhat large size must be employed to make the tests, that a great deal of material is going to be required to fill them. If this is to be all brick, the question arises whether it is possible to supply a standard brick for filling up the bulk of a charge and use a few only of the test brick which often must be shipped from a distance. Also the use of iron as a filling material, and also granite and other stones, has been proposed. The first series of tests on this line of argument were to test the utility of iron as an abrasive or filling material. Accordingly, charges of five bricks each were weighed out and small foundry shot, no piece of which weighed above 1½ lbs., and most of which did not exceed 8 ounces, was used to fill these charges up to a volume of 5, 10, 15, 20 and 25%. The losses on rattling showed a slightly decreased rate as the charge increased in volume, but the losses of all charges were only very slight and insufficient to show the relative quality of the bricks. Next cast iron bricks, weighing about 7¼ lbs. each, with rounded corners and edges, were used as a filling material in eight similar charges, two of each volume. The losses incident to their use were very severe and irregular—so much so that no idea could be had of the relative wear of the bricks. Besides breaking the bricks the cast iron broke the machines as well and was discontinued for that reason. Iron, therefore, in large or small pieces gave very unsatisfactory results as a filling material where the volume was maintained in the charge and only a few bricks employed in each test. Brick and stones were, therefore, the only available materials.

In order to obtain a more definite knowledge of the regularity of loss where all-brick charges of one kind of brick were employed, ten sets of charges, each of 10% volume, were rattled for 1,000 and 2,000 revolutions at a speed of 30 revolutions per minute in the 28x18 chamber. The tabulated losses showed a variation of about 4½% from the lowest to the highest, or a variation of about 20% of the total average loss, 10 above and 10 below. The averages found in this test for 1,000 and 2,000 revolutions were accepted as the standard loss for this material under these conditions, and were used as a basis of comparison in all further tests. Having thus established what the standard brick ought to lose when tested by itself, and within what limit variations might be expected, the next matter was to test the results of substitution of brick with stone filling materials.

Accordingly, a quantity of three typical stones, a limestone, a granite and a sandstone, was obtained, and pieces were broken and chipped into condition so that they each weighed substantially the same as the bricks, and their general outline was a rectangular one, as similar to a brick as was possible. Duplicate charges of 10% volume of each of these stones were rattled to ascertain their characteristic rate of wear. Then mixed charges, consisting of three bricks and the rest of the volume supplied with stone, were rattled in triplicate. The results of this test were unexpected. The bricks did not show a regular behavior at all; but in a number of cases they lost less than when rattled brick on brick.

But, inasmuch as the cost of fresh square blocks of stone, of approximately uniform weight, would be in excess of that of vitrified brick, it is apparent that no economy would result from their use, even if the results were satisfactory, which they were not. To be able to effect a saving, therefore, we should have to use the stones repeatedly. To test the effect of this action, charges were used composed of the bricks as before, with the balance of the volume made up to 10%, with rounded granite blocks, which had previously been rattled for not less than 2,000 revolutions. Seven such charges were tested, supplying a new block of granite when any of the old ones broke or wore down to less than 80% of the weight of one brick. The results, when marshalled into shape, show again very unexpected figures.

The losses were not only very erratic and irregular, but they were also very much higher on the average than those obtained with brick on brick, or brick on rough stones. The natural explanation of this is that the rounded granite becomes smooth and slippery and rolls readily, thus causing freer motion to the bricks and heavier blows.

The unsuitability of stones, either rough or smooth, either on grounds of economy or for its reliability and regularity of action, being proved, the only point as to selection of a filling material which remained to be investigated was the use of a brick filler, to be kept in stock at the testing laboratory and used as occasion presented. To get at the effect of various fillers of this sort, nine samples of paving bricks and blocks of various quality, and two samples of building material, ordinarily soft burnt, were used. Charges of these standard bricks each were weighed out and filled to the standard volume with each of the new material and rattled under standard conditions. This was repeated three times in most cases and the results tabulated.

The results are very unsatisfactory, so far as showing the method to be suitable is concerned. They show some facts of which no adequate explanation has presented itself. But they do show that even where bricks of the same weight and substantially the same rattling value are used, that the results are very fluctuating and uncertain, and not in any way fit to be used as a standard method.

There remain a few considerations which have not yet been submitted to direct test. Among these are the effect of water on the rate of wear. In other words, would a dry brick wear better than a wet one, or vice versa. Also, the effect of size has not been fully investigated, although we know that a large brick does not suffer so much as a small one. Its loss in ounces is approximately the same, but the percentage loss is less.

The following experiments and conclusions [illegible] the St. Louis Testing Laboratory, executed by F. F. [illegible]rring ton and presented by him personally, were brought before the commission in regard to the rattler test:

Standard Brick.—500 bricks from Purington Brick Co., Galesburg, Ill., were selected for uniformity from one kiln and shipped to St. Louis.

Rattler.—Diameter, 24 ins.; length, 42 ins.; provided with movable cross partition or diaphragm.

Experiment 1.—To find the effect of volume of charge. Results showed maximum loss at 15% volume, less at either 10 or 20%.

Experiment 2.—Effect of length, by moving diaphragm and testing chambers from 12 to 39 ins. Results showed no difference due to length, and only such variations above and below the average as variations in brick and process occasion.

Experiment 3.—Effect of speed. Charges of equal volume and in equal sized chambers were rattled at speeds from 20 to 40 revolutions per minute. The results showed, first, that the loss per revolution was substantially the same at all speeds tested, with a tendency to higher losses with higher speeds; that losses per minute vary directly with the speed.

Experiment 4.—In all the work recorded in the first three experiments the rattling was done in stages, from 10 minutes, 25, 40, 60, and 80 minutes, and weighings made after each period. These losses were plotted in curves, calculating and plotting each loss as the gross loss from the beginning. This gave, of course, gradually ascending curves, the reverse of those in Series 2 of the University tests. These curves, conducted on other materials, have shown that each kind of brick shows a characteristic rate of wear, more or less rapid at first, and decreasing more or less as the process continues. These curves, therefore, conducted on the plan inaugurated by Mr. Harrington, become very important and delicate means of determining the nature of a brick, since they not only show its gross loss, but indicate what its tendencies will be when exposed to actual conditions.

Credit is due to Mr. Harrington as being the first to bring out and use this characteristic wear curve for paving brick.

Experiment 5.—Effect of cast iron as an abrasive or filling material. The blocks of iron weighed 6 lbs. each. The bricks were five in number, and ten blocks were added and rattled, no reference being made to maintaining a definite percentage of volume. Result: The losses of the bricks were irregular and fluctuating and no characteristic curves could be drawn. The iron was condemned as an abrasive.

Experiment 6.—Granite was tested by itself and its characteristic curves could be drawn. The iron was condemned and the losses were found to vary after eighty minutes' rattling by 33% of the highest and 50% of the lowest. Also, the granite in nearly all cases gave curves not comparing in regularity with those of bricks, as its coarser structure made its losses irregular. Stone was therefore abandoned.

Experiment 7.—The effect of varying size of the brick on its rate of wear was investigated. Half bricks and whole bricks were tested, showing less wear on the whole brick. Also, three sizes of bricks, or rather three thicknesses of brick, from the same bar of clay were tested. The bricks were 8 × 3¾ ins. cross section and 3½, 3 and 2½ ins. brick, respectively. The percentage losses were least on the heaviest brick, and greatest on the lightest brick. This clearly indicates that it is not fair to compute the loss on a brick absolutely without reference to its size, and that this ought to be computed on its surface rather than its cubic contents.

Experiment 8.—The effect of overburning and underburning was also tested, showing in every case that overburnt bricks and underburnt bricks lost more than normally burnt bricks.

The experimental work at Columbus and St. Louis was done absolutely independently and without communication; and inasmuch as every experiment made by both observers has shown identically the same results the conclusions of both are certainly very greatly strengthened, and, in fact, can hardly be gainsaid.

Absorption Test.

The absorption test, originally assigned to Willard Beahan, was never completed by him, owing to his unfortunate loss of health. It was taken up, however, by Prof. H. A. Wheeler first, and later by Mr. Harrington, and brought to a satisfactory conclusion.

The porosity of burnt clay wares is well known to be the best index of their degree of chemical combination or vitrification; and, as many instances of failure of bricks by freezing have occurred in the earlier stages of the paving brick industry, the test has been, from the first, a most important and serviceable one. In order to understand the conditions under which uniformity of absorption

can be reasonably expected, the following tests were instituted by Mr. Harrington:

Experiment 1.—To determine what treatment is necessary to get the bricks completely dry. A special oven, made of sheet iron and well insulated with asbestos, was used. It contained 120 bricks at once and was heated by a Bunsen burner to a temperature ranging from 220° to 240° F. Ten sets of bricks, each made by a different firm, were placed in the drier, weighing them carefully to within one gram first, and then withdrawing them for reweighing at intervals of 6, 24, 48, 96 and 168 hours.

The results, when tabulated and reduced to a diagram, show that the water which is always found in burnt bricks, due probably to absorption from the atmosphere, cannot be expelled with even approximate accuracy with less than 48 hours' exposure to a temperature above the boiling point of water. The water continues still to escape even to 168 hours, or one week, but in small amounts only after 48 hours have passed.

Experiment 2.—Similar tests were next instituted on bricks which had been soaked for 24 hours previously; and, as bricks are received by the laboratory for test which have been exposed to rain and frost, it is plain that this test is only a fair comparison with such cases. Ten sets of bricks, two to a set, of different makes, were again dried after soaking. Conclusions are drawn from this series identical with those of series 1. Water continued to evaporate after a week's heating, but 48 hours sufficed to get rid of nearly all of it.

Experiment 3.—After having dried a series of bricks thoroughly, as indicated in the two preceding experiments, they were immersed in water, duplicates being taken in each case. They were weighed in one day, two days, three days and 1, 2, 4, 6, 8, 12 and 24 weeks. The results show that the absorption of hard burnt bricks was low in each case, and also that it followed the same laws as regulate the drying of the bricks before soaking. While after nearly six months' soaking the entire series was still absorbing water, still the great bulk of the water was taken in in every case in the first week, and generally in the first two or three days.

Experiment 4.—In order to discover whether the rate of absorption is materially changed by exposing the interior of a brick to the action of water, a series of tests composed of whole bricks, half bricks, bricks with both ends broken off, leaving the middle section intact, and lastly small pieces from the center of bricks, obtained from the crushing or cross-breaking tests, were dried and soaked as before for a period of twenty-four weeks, with periodic weighings as before. The results of this exhaustive test clearly show:

First.—That broken bricks always absorb more water than whole ones for either long or short periods.

Second.—That small pieces of brick from the interior are only satisfied after soaking for eight weeks.

Third.—That small pieces absorb more proportionately than either half bricks or whole bricks of the same manufacture.

The results of this very admirable series of tests by Mr. Harrington show the following points:

1. That to obtain accurate figures as to the absorption of any hard brick will require not less than four days' drying and eight weeks' soaking.

2. That only roughly approximate figures are obtained within time limits which would be short enough to make the figures useful for ordinary competitive tests of material for immediate use.

3. That only rattled bricks should be used for absorption test, as the absorptive power of the brick in use is certainly increased by its chipping and grinding under traffic.

4. A careful series of tests on bricks of the same sample sets was made by rattling, and a close comparison of the tabulated and plotted data was made. No connection between losses by rattling and percentages of absorption could be determined to exist. Bricks of high absorption are just as likely to show a good rattling test as a bad one inside the limits shown by this set of samples.

In the same connection, the results of a series of experiments made some time ago at the Ohio State University may be quoted.

A series of bodies was made, purposely varying them so as to secure a regular gradation of vitrification when burned at the same heat. These were burned and cooled, and after various physical measurements had been made they were finally rattled in a small ball mill. Their losses being duly recorded, they were soaked to complete saturation and their percentage of absorption determined. The results, when plotted, showed very beautifully that the loss by abrasion was directly proportioned to the gain by absorption; those gaining the greatest weight by soaking also lost the greatest amount by abrasion. The result is in direct accord with the well-known facts. Every paving brick maker knows that if his brick are not burnt hard they will suffer not only by abrasion but by frost.

But the point which is to be drawn from Mr. Harrington's work, which will doubtless commend itself to all brickmakers and users, is that where bricks have been burnt hard enough to endure a satisfactory rattler test, it is certain that they will not absorb water enough to cause their damage by frost. And since the absorption test, as ordinarily executed in the past, has been ridiculously incomplete and inefficient, and must be very greatly extended in duration and preliminary drying to even approximate the facts, it seems that the value of the test is hardly likely to repay one for its proper execution.

Cross Breaking.

The third subject to receive examination was that of structural strength. The tests usually applied in the investigation of this subject are cross breaking and crushing. None of the regularly appointed members of the commission had access to an accurate testing machine of sufficient capacity to crush a whole brick. And in the option of the commission it is essential that this shall be done in order to get results of the most reliable sort. Hence no new work has been executed on this test, but a review of the data already in existence was made. In regard to the cross breaking test, Mr. Harrington, under the direction of Mr. M. L. Holman, the Water Commissioner of St. Louis, has made a most elaborate examination of the proper methods of cross breaking to give consistent and proper results.

The machine used by Mr. Harrington was a hydraulic press designed by Mr. Holman, which was made the subject of very careful calibration before its results were considered as bearing on the point in view. It is too much to attempt to describe at this time, beyond stating that the pressure is applied from above by insensible stages, by a straight knife edge of rounded cross section, so that no cutting of the skin of the brick occurs at pressures necessary to break it. The lower knife edges which support the brick also were made the subject of special test, and were only finally determined after prolonged trials. The common straight, sharp knife edges in use have an effect of concentrating strains on a brick which cause rupture along certain lines of stress and at lower pressures than the brick is really capable of sustaining when differently supported. After getting the machine under complete control so that its action was well understood and its tendencies corrected the cross breaking of a large number of samples of brick was begun. Each sample consisted of ten bricks, and the average of these ten results was taken as being the structural strength of the material in question. Besides the average, the maximum and minimum were noted for each set of ten.

After tabulation of these data an attempt was made to find out the relation, if any, existing between the rattling tests and cross-breaking tests of the same makes of bricks. No relationship could be found in either direction. Bricks of low structural strength often stood high rattling tests, and vice versa. Also, brick of the same make varied very greatly between extremes, so that an average often failed to give confidence as being really a characteristic figure for the material. Beyond question, cross breaking tests, conducted as carefully and on as good machinery as above described do indicate something of the structural strength of bricks. But, also, brick in actual use in street paving are almost never submitted to strains of this character, nor to that of crushing; and hence the data obtained, even if they were thought to be characteristic, would still fail to show fitness or unfitness for this use.

The next subject taken up for discussion was that of the tests of hardness and specific gravity. Mr. Harrington submitted data obtained from ten samples of paving bricks, showing a range in specific gravity from 2.19 up to 2.41, the majority falling between 2.25 and 2.35. The hardness of even fairly well burned paving brick has been proved to lie very close to 6 in Moh's scale (Feldspar), and it is not possible by any known process or treatment to enable them to attain a hardness of 7 (quartz), though they may considerably exceed 6. The comparatively small range, as measured in this scale (Moh's), and the impossibility at this time of suggesting or applying any other test for hardness, make the value of the test seem doubtful. If the hardness is much below 6 it can be detected as quickly and as surely by other means and by the color of the ware. No attempt to obtain any clew to a relationship between specific gravity and rattling, or absorption or cross breaking has proven successful. The heavier bricks, as a rule, are the better bricks, but not always. In view of these facts the following resolution was passed:

"Whereas, After careful consideration of all the data as to hardness and specific gravity accessible to the commission, no relationship between these qualities and those necessary for good paving brick can be shown to exist; therefore,

"Resolved, That the commission recommends that these tests be abandoned as unnecessary."

The commission then listened to a report from Prof. Orton on the effect of the structure of paving materials on their power to withstand wear by impact or abrasion. The investigation of this matter had been authorized by the commission at its meeting in July, 1895, and the work had been begun soon after. The importance and value of the results obtained were fully recognized, but in the judgment of the commission the subject lay outside of the strict limits of its scope. According to the resolution which created it, its work was to discuss and recommend a standard method of making paving brick tests, and no authority is given to assign specific standards of quality or to recommend changes in the present systems of manufacture, even in the belief that they are furthering the cause of good paving. For this reason the commission refused to give the matter a place in its official report, while sanctioning the expenditure of any funds which had been used for this purpose and strongly recommending to the Association that it should hear and take action on the matter when presented separately. In the conclusion of its labors, the commission passed the following resolution:

"Whereas, The thanks of this commission are due to the Canton Brick Co., of Canton, O., who donated 4,000 brick for their use, and the Purington Paving Brick Co., of Galesburg, Ill., who donated 1,000 brick to the St. Louis Testing Laboratory for a similar purpose; and,

"Whereas, The labors of this commission have been very greatly assisted and the value of their conclusions very greatly enhanced by the help of Prof. H. A. Wheeler, of the Missouri Geological Survey, Mr. F. F. Harrington, of the St. Louis Testing Laboratory, Mr. M. L. Holman, director of the St. Louis Testing Laboratory and Water Commissioner of St. Louis; and Prof. J. B. Johnson, of Washington University; therefore, be it

"Resolved, That this commission recommends that the National Brick Manufacturers' Association shall extend its thanks to the gentlemen and firms above named for their valuable co-operation and aid."

Following are the standard specifications prepared by Prof. Orton in accordance with the investigations which are described above:

Standard Specifications for the Rattler Test for Paving Brick.

1. Dimensions of the Machine.—The standard machine shall be 28 ins. in diameter and 20 ins. in length, measured inside the rattling chamber. Other machines may be used varying in diameter between 20 and 30 ins., and in length from 18 to 24 ins., but if this is done a record of it must be attached to official report. Long rattlers may be cut up into sections of suitable length by the insertion of an iron diaphragm at the proper point.

2. Construction of the Machine.—The barrel shall be supported on trunnions at either end; in no case shall a shaft pass through the rattling chamber. The cross section of the barrel shall be a regular polygon, having 14 sides. The heads and staves shall be composed of gray cast iron, not chilled or case hardened. There shall be a space of ¼-in. between the staves for the escape of dust and small pieces of waste. Other machines may be used having from 12 to 16 staves, with openings from ⅛ to ⅜ in. between staves, but if this is done a record of it must be attached to the official report of the test.

3. Composition of the Charge.—All tests must be executed on charges composed of one kind of material at a time. No test shall be considered official where two or more different bricks or materials have been used to compose a charge.

4. Quantity of the Charge.—The quantity of the charge shall be estimated by its bulk and not its weight. The bulk of the standard charge shall be equal to 15% of the cubic contents of the rattling chamber, and the number of whole brick whose united volume comes nearest to this amount shall constitute a charge.

5. Revolutions of the Charge.—The number of revolutions for a standard test shall be 1,800, and the speed of rotation shall be 30 per minute. The belt power shall be sufficient to rotate the rattler at the same speed, whether charged or empty. Other speeds of rotation between 24 and 26 revolutions per minute may be used, but if this is done a record of it must be attached to the official report.

6. Condition of the Charge.—The bricks composing a charge shall be dry and clean, and as nearly as may be possible in the condition in which they are drawn from the kiln.

7. The Calculation of the Results.—The loss shall be calculated in percentage of the weight of the dry brick composing the charge, and no result shall be considered as official unless it is the average of two distinct and complete tests, made on separate charges of brick.

Standard Specifications for the Absorption Test for Paving Brick.

1. The number of bricks for a standard test shall be 5.

2. The test must be conducted on rattled bricks. If none such are available, the whole bricks must be broken in halves before treatment.

3. Dry the bricks for 48 hours at a temperature ranging from 230 to 250° F. before weighing for the initial dry weight.

4. Soak for 48 hours, completely immersed in pure water.

5. After soaking, and before weighing, the bricks must be wiped dry from surplus water.

6. The differences in weight must be determined on scales sensitive to one gram.

7. The increase weight due to water absorbed shall be calculated in percentage of the initial dry weight.

The following resolution was then presented, and after most careful consideration of all the facts brought out by the data of Messrs. Harrington and Orton, was adopted unanimously:

"Resolved, That in the opinion of the commission, any paving brick that will satisfy the requirements of reasonable mechanical tests will not absorb sufficient water to prove injurious to it in service. We therefore recom-

mend that the absorption test be abandoned as unnecessary, if not actually misleading."

Standard Specifications for the Cross-Breaking Test of Paving Brick.

1. Support the brick on edge, or as laid in the pavement, on hardened steel knife edges, rounded longitudinally to a radius of 12 ins. and transversely to a radius of ⅛-in. and bolted in position so as to secure a span of 6 ins.

2. Apply the load to the middle of the top face through a hardened steel knife edge, straight longitudinally and rounded transversely to a radius of one-sixteenth inch.

3. Apply the load at a uniform rate of increase till fracture ensues.

4. Compute the modulus of rupture by the formula

$$f = \frac{3\,W\,l}{1\,b\,d^2}$$

in which

f=modulus of rupture in pounds per square inch.
w=total breaking load in pounds.
l=length of span in inches=6.
b=breadth of brick in inches.
d=depth of brick in inches.

5. Samples of test must be free from all visible irregularities of surface or deformities of shape, and their upper and lower faces must be practically parallel.

6. Not less than ten brick shall be broken and the average of all be taken for a standard test.

Standard Specifications for the Crushing Test of Paving Brick.

1. The crushing test should be made on half bricks, loaded edgewise, or as they are laid in the street. If the machine used is unable to crush a full half brick, the area may be reduced by chipping off, keeping the form of the piece to be tested as nearly prismatic as possible. A machine of at least 100,000 lbs. capacity should be used, and the specimen should not be reduced below 4 sq. ins. of area in cross section at right angles to direction of load.

2. The upper and lower surfaces should preferably be ground to true and parallel planes. If this is not done, they should be bedded in plaster of Paris, while in the testing machine, which should be allowed to harden ten minutes under the weight of the crushing planes only before the load is applied.

3. The load should be applied at a uniform rate of increase to the point of rupture.

4. Not less than an average obtained from five tests on five different bricks shall constitute a standard test.

The following resolution was then presented and unanimously adopted:

"Whereas, From the experimental work done so far by this commission, or by others so far as is known to us, in the application of the cross-breaking and crushing tests to paving bricks, it is not possible to show any close relationship between the qualities necessary for a good paving material and high structural strength as indicated by either of these tests,

"Resolved, That for this reason the commission recommends that these tests shall be considered as purely optional in the examination of paving material, and not necessary as a proof of excellence."

BOOK REVIEWS.

HYDRAULIC CEMENT; ITS PROPERTIES, TESTING AND USE.—By Frederick P. Spalding, M. Am. Soc. C. E., Assistant Professor of Civil Engineernig, Cornell University. New York: John Wiley & Sons. 12mo.; cloth; pp. 265; 34 illustrations; $2.

For a number of years the engineer desiring to study the latest authoritative facts and opinions regarding hydraulic cements and their use in engineering construction has had before him the rather tedious task of searching through the files of the different engineering journals and technical society proceedings to find what he wished. Such information could not be had summarized in any one book. Indeed, since the tests made by Gen. Q. A. Gilmore in 1875-6, the results of which were shortly afterwards embodied in his several books on cements and concretes, nothing in the shape of a handy manual on cements has appeared in America until very recently. In England the conditions had been somewhat better, but it was among the French and German books only that really up to date treatises were to be found for a long time, and for many American engineers the contents of these books were hidden wealth. This fact was the more to be regretted because it has been from the European government testing laboratories that most of the completely worked out and carefully studied data regarding the qualities, testing and use of hydraulic cements have come. The truth of this statement is abundantly testified by the pages of the book now before us, and was similarly noted in Prof. Charles D. Jameson's extended monograph, reviewed in our issue of Aug. 1, 1895.

Professor Spalding has divided his manual into nine chapters and an appendix, and a very fair idea of its contents may be obtained from the titles of these chapters. These are as follows: I. Hydraulic Lime; II. Classification and Constitution of Cement; III. Setting and Hardening of Cement; IV. Soundness of Cement; V. Methods of Testing Cement; VI. Tests for Strength of Mortar; VII. Tests for Soundness; VIII. Special Tests; IX. Cement Mortar and Concrete; Appendix, Specifications for the Reception of Cement.

The first four chapters, as will be seen, relate to the more general characteristics of the classification, constitution and physical and chemical qualities and behavior of limes and cements in manufacture, setting and hardening. The various theories which have been advanced by different experimentors to explain the phenomena of setting and hardening are given, and the effect of environment, adulterants, climatic conditions, etc., on the rapidity and effectiveness of these processes as determined by the most reliable experiments are summarized briefly. In chapters five to eight, inclusive, the subject of testing methods is taken up, and the several different tests, the object sought by each, the construction and manipulation of testing machines, and finally the value of the evidence gained for practical use, are fully discussed. The chapter on tests for soundness, together with the previous chapter, discussing the various causes of unsoundness, in view of the great variance of opinion upon these points, are deserving of particular attention, because of the conservative and temperate manner in which the subject is treated. In chapter IX. and the appendix brief space is given to a discussion of the practical use of cement mortar and concrete in actual construction.

The book can in no sense be called a treatise on the subject with which it deals, and doubtless the author did not intend it to be, but it is certainly the best arranged and nearest up to date manual on cements in English. It fails, however, in being entirely without an index. The publishers' work is uniformly good.

OIL AND GAS YIELDING FORMATIONS OF LOS ANGELES, VENTURA AND SANTA BARBARA COUNTIES, CALIFORNIA.—Part I. By W. L. Bates, M. E., Field Assistant. Bulletin No. 11. California State Mining Bureau, J. J. Crawford, State Mineralogist. Paper; 9 × 6 ins.; pp. 94; illustrated. Address State Mining Bureau, San Francisco. 50 cts.

This pamphlet enters fully into the geological formation in which oil is found in the counties named, the location and depth of wells, the methods of drilling and refining oil, etc. Maps and photographs illustrate each locality, and the author discusses the possibility of further development. The Bulletin deals chiefly with the geological formations in which oil is found, and no generalization or summary of results obtained is given in area or product.

An interesting part of the report states that oil is largely used as fuel on the Southern California Ry. between Barstow and San Diego. More than half of the locomotives there are now equipped with burners devised by Mr. W. Booth and improved by the Santa Fe Company. Experiments extending over six months demonstrate the superiority of oil over the solid fuel available, and an average of results show that 4 barrels of oil will do the same work as 2,200 lbs. of Nanaimo coal. Experiments extending over 16 days with a freight engine, 19 × 28-in. cylinders, gave an average evaporation of 13.11 lbs. of water to each pound of coal consumed. With coal at $6.65 per 2,000 lbs. and oil at $1.33 per barrel, the money saving effected was equivalent to 27.1%. The oil used had a specific gravity of 23° B. In January, 1896, oil was used as fuel on 25 locomotives, equally divided between passenger and freight service. The record for these 25 locomotives stands as follows:

Oil consumed	2,077 tons
Distance traveled	87,063 miles
Average cost per mile	14.39 cts.

The oil here used had a specific gravity of 15° B. In the same month of January 25 other locomotives performed practically the same work with coal used as fuel at $6.60 per 2,000 lbs. The actual cost of the coal fuel was 23.20 cts. per mile, showing a saving in money of 37.97% in favor of oil, costing $6.03 per 2,000 lbs. In December, 1895, an overland passenger engine, 19 × 26-in. cylinders, ran 7,347 miles and consumed 142.2 tons of oil; the same service with coal consumed 294 tons. With the fuel at the above prices, the oil cost 11.75 cts. and the coal 26.41 cts. per mile run, equivalent to a saving of 55.5%. In these experiments steam from the boiler was used to atomize the oil and the oil was heated by a steam-coil to a temperature of 100° to 120° F. Two 4-in. flat-mouthed burners were used with each engine, and the fire-box was protected by fire-brick, with a fire-brick arch at the back of the flues. Oil is also used as fuel by the Los Angeles Electric Railway Company, the Los Angeles Pressed Brick and Terra-Cotta Company, the California Sewer Pipe Works, in heating the court house by steam and at other places. As a result of the experiments made the relative fuel value of oil and coal for the Los Angeles region is set down as follows:

1 ton Wellington coal = from	2.50 to 3.62 bbl. oil
1 ton Nanaimo coal =	3.10 bbl. oil
1 ton good coal =	4.00 bbl. oil

In 1895 the State Mining Bureau made a series of tests to meet a prevailing opinion that the oils of high specific gravity had a much less fuel value than those of low specific gravity. Samples of oil were tested ranging from 13° B. to 34° B., with a result showing from 9,999 to 10,381 kilo-calories, or sufficient to demonstrate that there was no great difference in the relative calorific value of the samples tested. From other experiments the Bureau computed the following ratios of fuel value: Assuming that one pound of coal is equal to one heat unit, one pound of oil is equivalent to 1.526 heat units.

TABLES FOR EARTHWORK COMPUTATIONS. By C. F. Allen, M. Am. Soc. C. E., Assoc. Professor of Railroad Engineering, Massachusetts Institute of Technology. Published for the author by D. Van Nostrand Company, New York. 8vo.; cloth; pp., 38. $1.50.

While admitting the advantages of diagrams for rapid use, Mr. Allen finds some engineers who still prefer tables, as being more portable, allowing of greater precision and requiring less personal judgment in use. This book is prepared for the latter class. Table I. gives the volume by the method of averaging end areas; and Table II. gives a "prismoidal correction" to be applied to the results obtained by Table I., when this refinement is deemed necessary. The method of using this table is fully described, especially as Table II. applies to irregular sections. Table I. gives the quantities in cubic yards for 50 ft. lengths of triangular prisms; and the table of prismoidal corrections applies to quantities in yards for 100 ft. sections. A third table gives quantities for level sections, 50 ft. long, with varying base and side slopes.

A BOILER EXPLODED at the Leasdale mine, Carnegie, Pa., on April 26, fatally injuring one man and slightly injuring four others.

A NEW SUPERVISING ARCHITECT OF THE TREASURY Department is to be appointed, and Secretary of the Treasury Gage has requested the resignation of the present incumbent, Mr. W. N. Aiken. The position now comes under the civil service rules. It is believed at Washington that the next supervising architect will be selected by means of an examination conducted by a board of architects of national reputation. The salary of the position is $4,500 per annum; a small compensation for an official responsible for the design and structural stability of buildings costing the government millions each year.

MANUFACTURED EXPORTS STILL INCREASE, says the "Journal of Commerce." The exports of manufactures for March exceeded by $2,000,000 the heaviest previous totals for the same month, and exceeded by 30% the total for March, 1896, and by 60% those of March, 1895. The total value of manufactured goods sent abroad in March of this year was $25,874,469, or 30% of all exports. The steady growth of this class of exports in late years is shown by the following figures: Total export of manufactured goods in 1895, $201,153,663; in 1896, $253,688,527 and a continuation of the gains shown in the first three months of 1897 would result in a total of more than $300,000,000 for the current year. In 1870 our total exports of this character amounted in value to $68,277,764; in 1880 they were $102,856,015, and in 1890, $151,102,376. In 1870 manufactured goods represented 15% of our total exports, whereas in 1897 they will represent nearly 25% in a total export value of $1,076,000,000.

THE STRAIGHTENING OF THE ST. LAWRENCE River, below Ogdensburg, is to be undertaken by the Dominion government and proposals are now asked for. To avoid the present circuitous route, it is proposed to dig a channel, 2½ miles long, from the head of the Galops Canal up river to a point opposite Johnstown, just below Prescott. This channel will have a bottom width of 200 ft., and will be 17½ ft. deep at ordinary water. The estimated cost is $800,000. This canal will enable Canadian vessels to pass the Canadian canals, to and from the lakes, without running into American waters.

THE TENNESSEE CENTENNIAL EXHIBITION was opened at Nashville, on May 1, with appropriate ceremonies. The machinery was started by President McKinley's touching an electric button in the White House in Washington. The exhibition promises to equal in attractiveness and to be as successful in every respect as the one held in Atlanta two years ago. Over $1,000,000 has been spent in its preparation, of which the general government appropriated $130,000, the state legislature $50,000, and the county of Davidson and city of Nashville, $150,000. The architecture is mostly classic and includes a reproduction of the Parthenon at Athens, and of the Rialto in Venice. Besides there are buildings devoted to history, to commerce and manufactures, to agriculture, to transportation, to education and hygiene, to minerals and forestry, to machinery, a negro building, a woman's building, and others of smaller dimensions. The Machinery Hall is 375 × 138 ft. in area, the Commerce Building, 591 × 256 ft. and the Agriculture Building 300 × 200 ft. A "Vanity Fair" takes the place of the "Midway Plaisance" of the Chicago exhibition, and it contains instead of a Ferris wheel, a giant "See-saw," by which a carload of people is raised 200 ft. above the ground.

THE GENERAL ELECTRIC COMPANY has issued its annual report for the year ending Jan. 31, 1897. The gross earnings were $12,820,396, as compared with $13,315,667 for 1896, and the expenses were $11,207,389, as compared with $11,759,857 for the previous year. The net profits for the last year were $959,658, as against $877,646 in the year ending Jan. 31, 1896. The volume of business secured in the first three months of the current year is reported as slightly in excess of that for the same period in any of the three preceding years. The general balance sheet, on Jan. 31, 1897, shows total assets and liabilities of $43,380,031.